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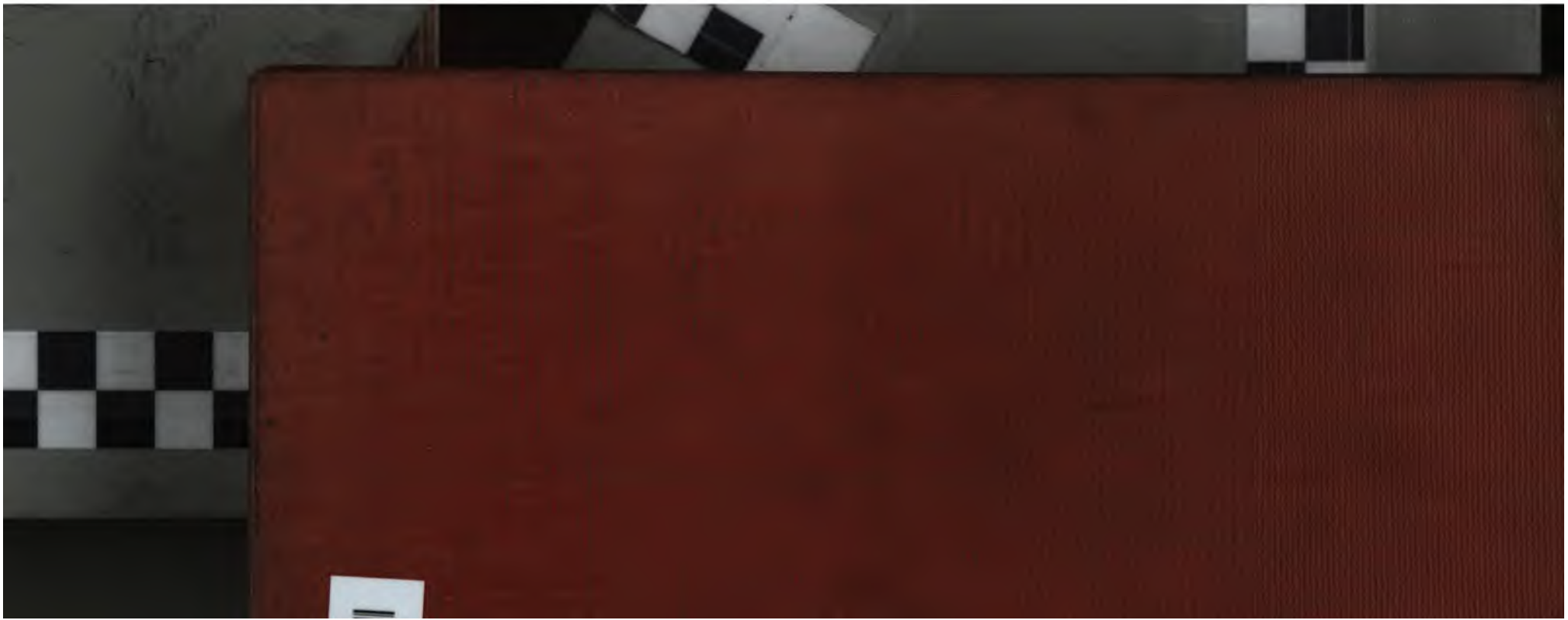
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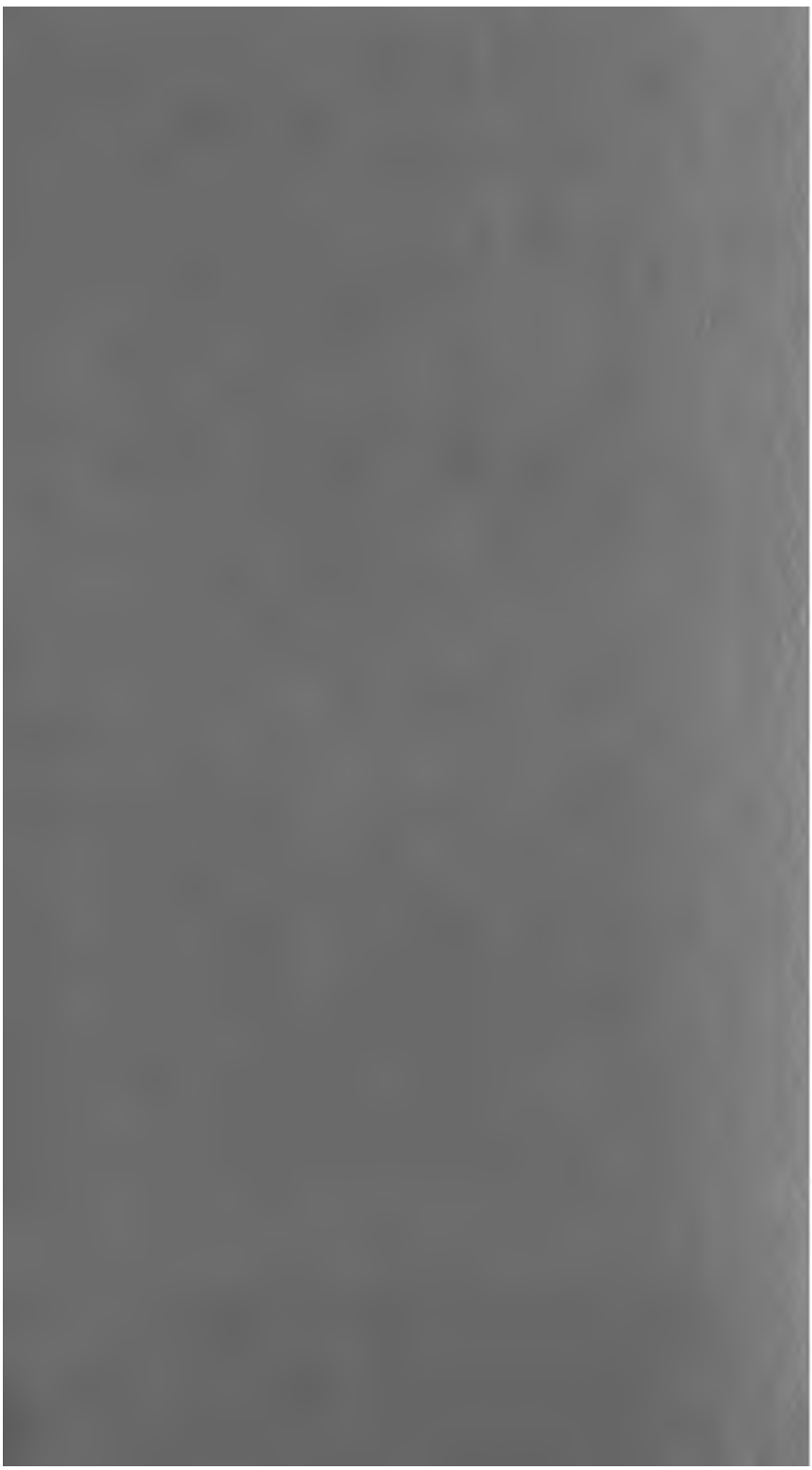
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NEW YORK
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COTTON MULES
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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the

indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

This volume describes the spinning of cotton yarn and the treatment of the yarn preceding its insertion into the loom. The two principal types of spinning machines, the ring frame and the cotton mule, are both treated in detail and due consideration given to the matter of adjustments, location of faults, calculation of change gears, etc. After spinning comes the process of twisting, in which several threads are combined into one. Next, the various spooling processes are described, processes that have for their object the arrangement of the yarn in a form suitable for the succeeding processes of warping and slashing. In the chapter on warpers, the principal types are considered, such as the Entwistle and the Draper warpers. Then comes the process of slashing, in which the yarn is provided with size by which means it is enabled better to withstand the frictional stresses in the loom. The final part of the volume is devoted to the process of chain warping, in which the yarn is arranged in a manner that will allow it to be bleached, dyed, or printed before being inserted into the loom.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part, when the subject is divided into two or more parts, is complete in itself; hence, in order to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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RING FRAMES

(PART 1)

INTRODUCTION

GENERAL CONSIDERATION OF SPINNING MACHINES

1. As the roving that is produced by the last fly frame is in a suitable condition to be converted into yarn, it undergoes the operation of **spinning**, which is a continuation of the fly-frame processes, although the machines employed differ to a very large extent. The principal object of the fly-frame processes is to attenuate the sliver so as to reduce it to roving; the machines used in spinning continue this attenuation and reduce the roving to yarn of the size required. The chief point of difference between the effects of these two processes on the roving is in the amount of twist inserted; in the fly frames, only sufficient twist is put in to enable the fibers to hold together and thus permit the roving to be unwound at the next process without breaking, while with the machines used in spinning, after the material has been reduced to the correct size, it is necessary to put in sufficient twist not only to prevent the fibers from pulling apart but also to give the yarn all the strength that is required for the purpose for which it is intended.

Cotton yarn is spun on four kinds of **spinning machines**; namely, the **ring frame**, the **throstle frame**, the **self-acting mule**, and the so-called **hand mule**. The term *frame spinning* includes both the ring frame and the throstle

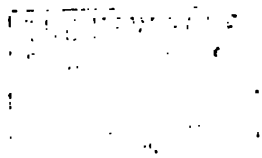
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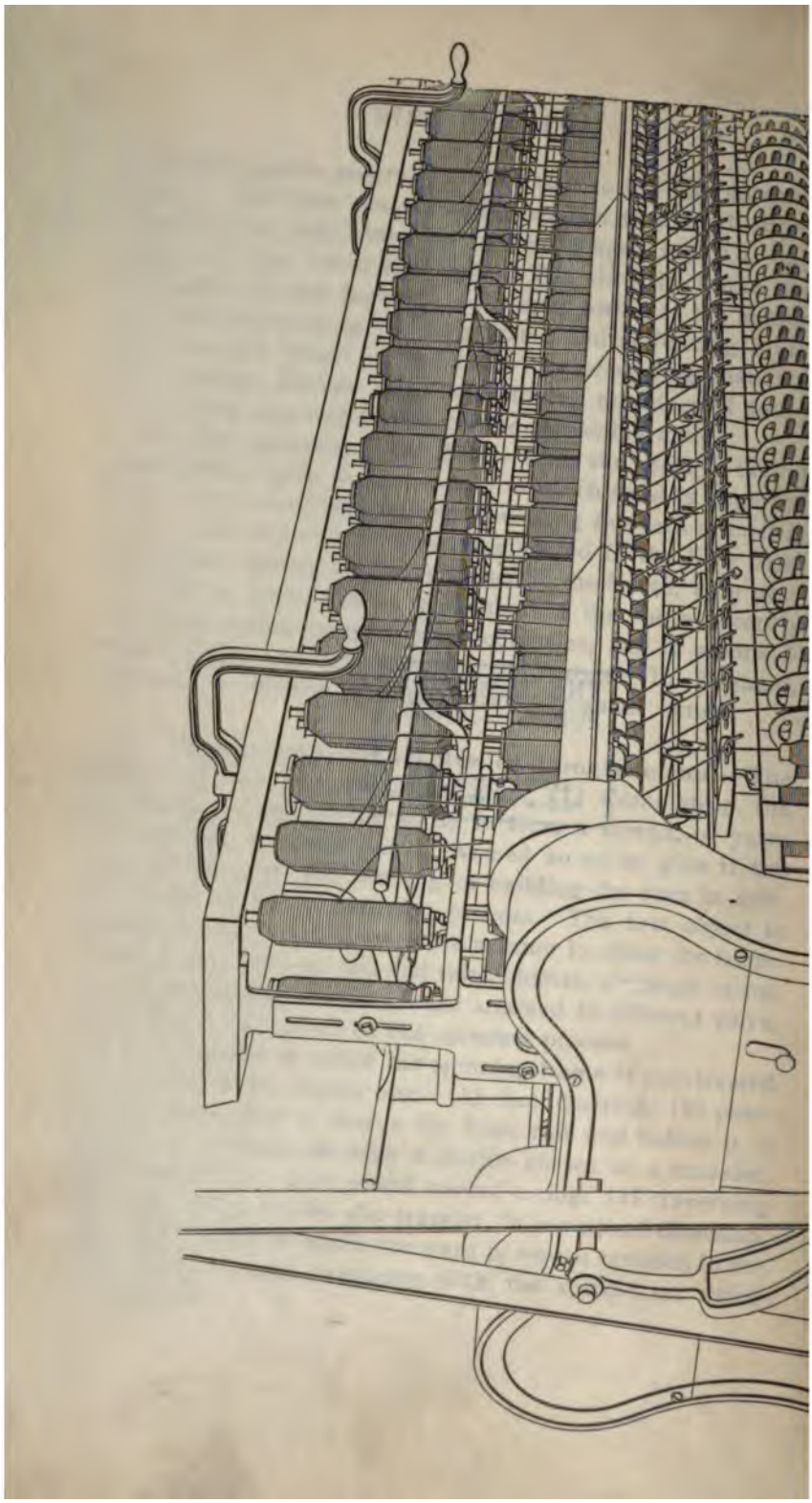
frame, but is now generally applied only to the ring spinning frames. The term *mule spinning* applies to the self-acting mule and the hand mule, but, generally speaking, it is only applied to the self-acting mule. The throstle frame and hand mule are fast passing into disuse, owing to the numerous improvements in the ring frame and self-acting mule, and are only found in the older manufacturing districts; consequently, the two principal spinning machines of today are the ring spinning frame and the self-acting mule.

The ring spinning frame differs from the mule in that it spins continuously, in the method in which twist is imparted to the yarn, and in the manner of winding the yarn after it is spun. This machine is very largely used in the New England States; almost exclusively used in the South; is in general use in India, China, and other of the more recently developed cotton-manufacturing countries; and to a considerable extent on the continent of Europe. In England, however, it is used to a comparatively small extent.

2. Objects and Principles of Construction.—The objects of spinning machinery are: (1) Completing the attenuation of the roving so as to form a thread, or yarn; (2) twisting the yarn that is formed so as to give it the required strength; (3) winding or building the yarn in suitable form for use at the next process. The first object is usually accomplished in the same manner in either the frame or the mule. The second and third objects, although requisite in all spinning machines, are attained in different ways, according to the nature of the spinning process.

The principles on which the spinning frame is constructed to accomplish its objects are: (1) Roll drafting; (2) passing the yarn, after it leaves the front roll and before it is wound on a bobbin, through a device known as a traveler, which rotates at a high speed around a ring; (3) traversing the ring, which carries the traveler, in a vertical direction, while the bobbin on which the yarn is wound remains in the same place, simply revolving with the spindle on which it is placed.





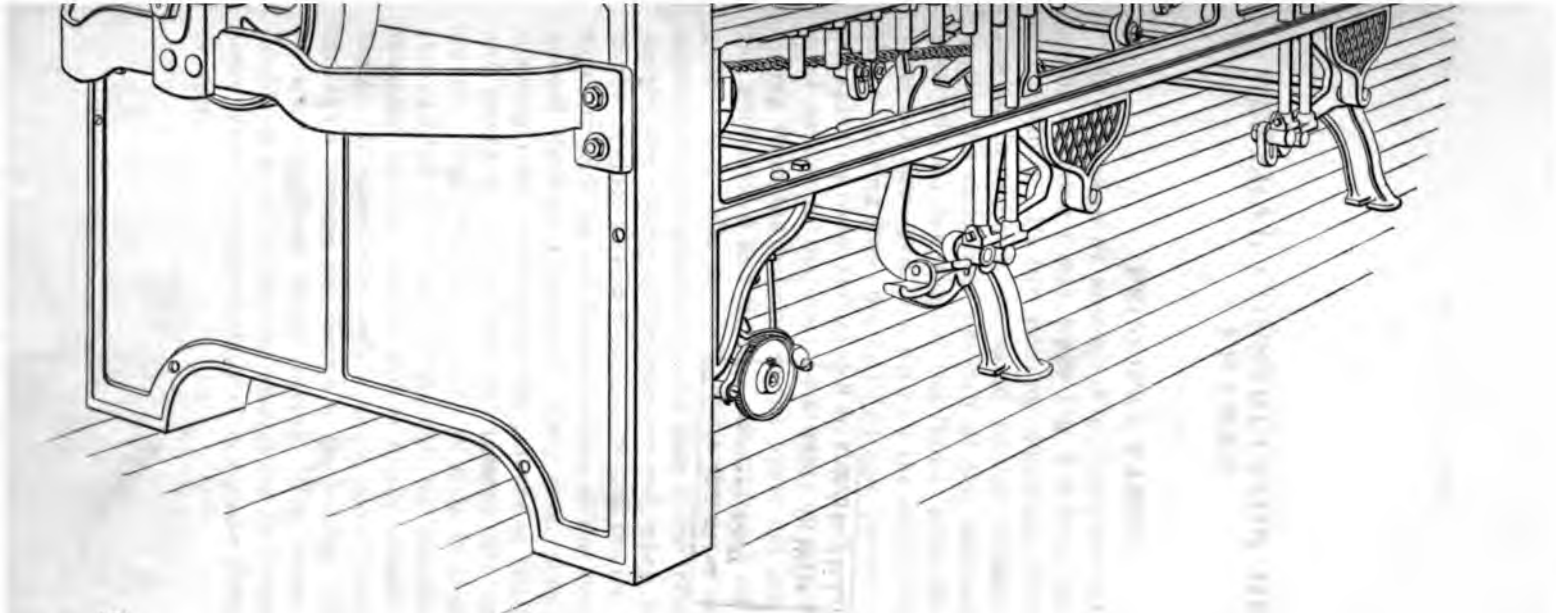


FIG. 1


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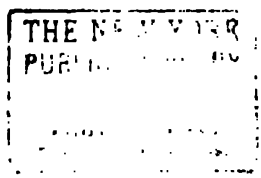
GENERAL CONSTRUCTION OF RING FRAMES

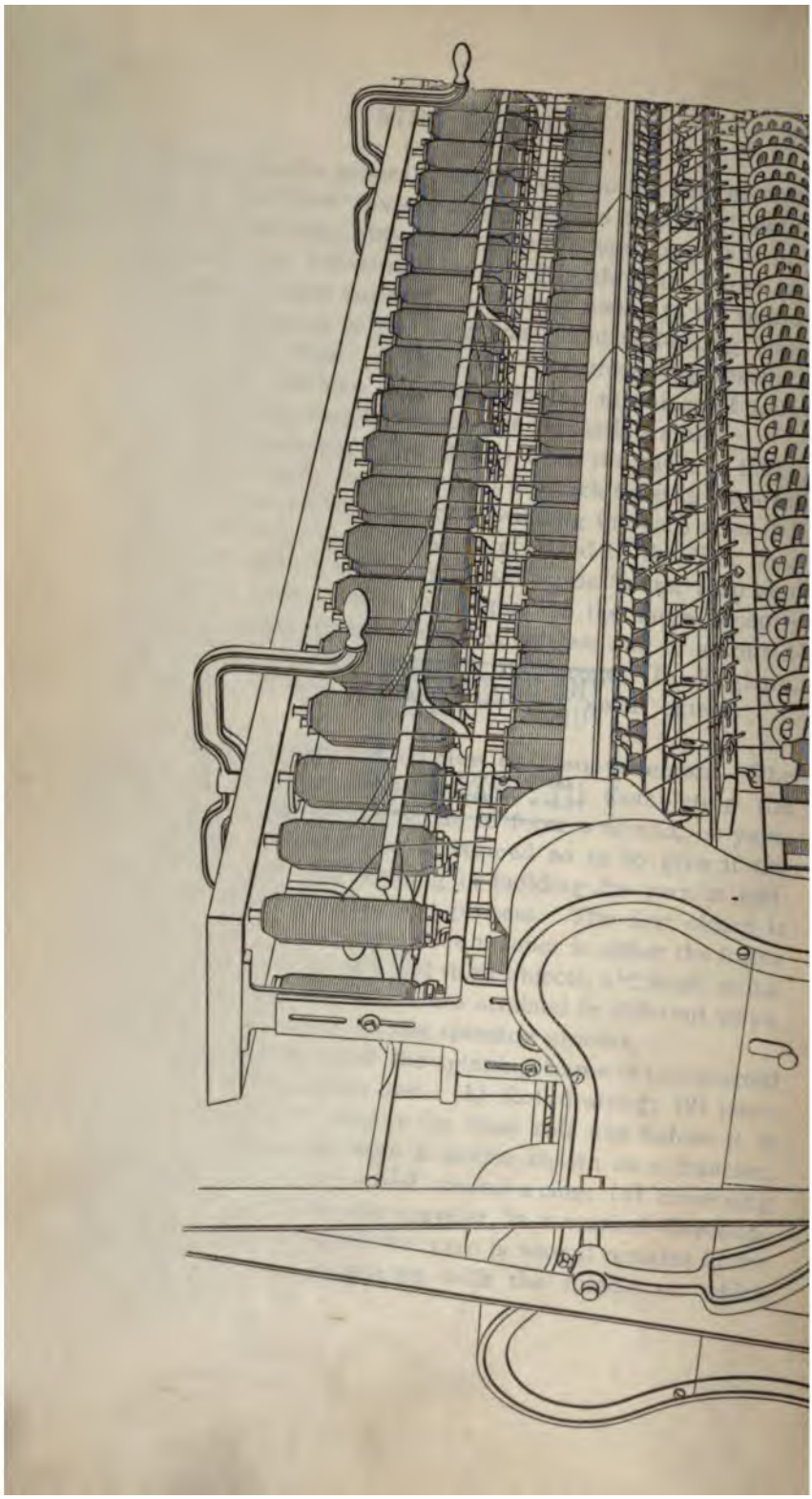
PRINCIPAL PARTS

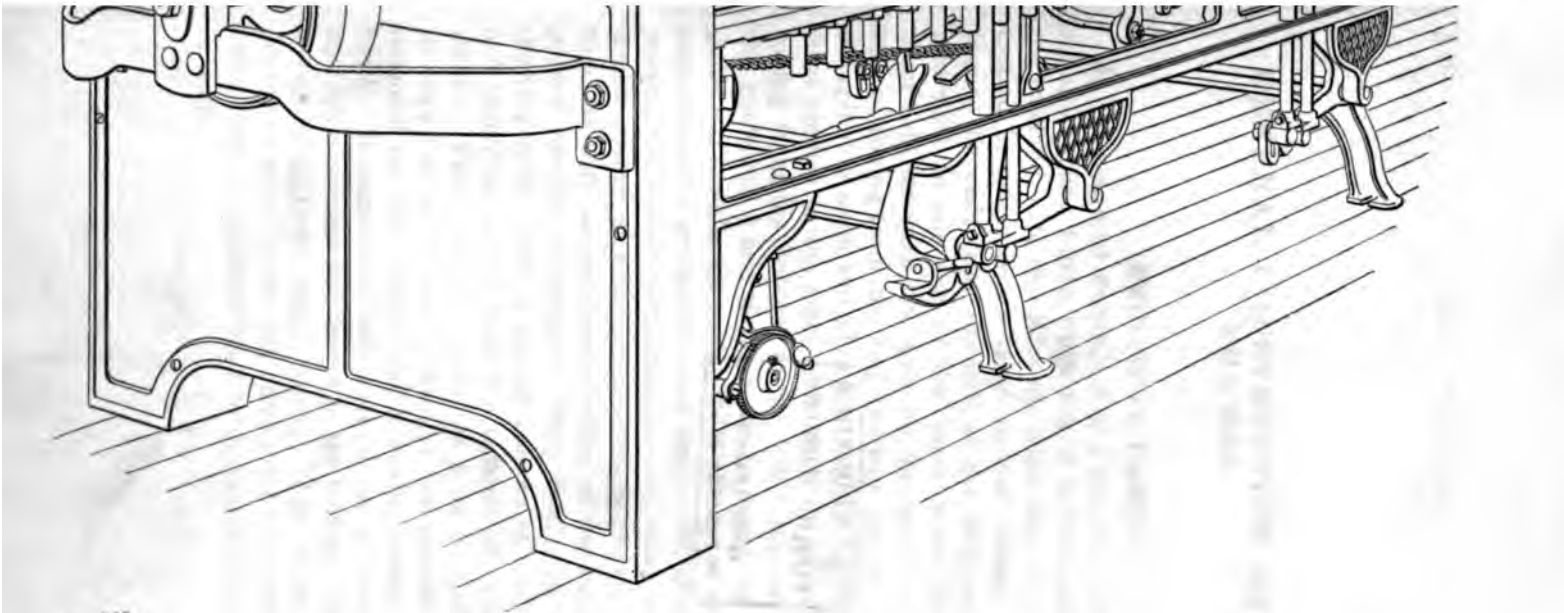
3. Passage of Stock.—Fig. 1 is a view of a portion of a ring spinning frame, while Fig. 2 is cross-section through the machine. Its two sides are duplicates, the roving being treated in precisely the same manner on each side of the frame, the ends from one-half of the bobbins being spun into yarn on one side of the frame, while those from the other half are spun into yarn on the other side. The bobbins of roving from the last fly-frame process are taken to the spinning room and placed in the creel *a*, which is somewhat similar to the creel used on fly frames. The ends of roving from the bobbins in the lower set are passed over the guide rod *b* and through the trumpets on the traverse guide rod *c*, while the roving from the upper set of bobbins passes over the guide rod *a*, and then to the traverse rod. In passing the roving to the traverse rod, when spinning from double roving, an end from a bobbin in the top row is taken together with an end from a bobbin of the bottom row and passed through a trumpet. They then pass through the drawing rolls, where a certain amount of draft is inserted, and emerging at the front are twisted into one strand, or thread. The thread, or *yarn*, as it is now called, passes through the guide wire *e*, through the traveler *f*, which is mounted on the ring *g*, and is finally wound on the bobbin *k*. In some cases only a single end of roving is passed through a trumpet and thence to the bobbin. This is known as spinning from single roving. The terms single and double as used in this case should not be confused with the same terms sometimes used to designate defects in roving or yarn.

4. Creel.—Owing to the fact that the roving must be delivered to both sides of a spinning frame, the creel of this machine differs from the ordinary construction, being so made that the roving may be passed to both sets of drawing rolls. The creel of a spinning frame may be one-, two-, or three-tier deep, the one on the frame shown in Figs. 1 and 2 being a two-tier creel. It consists of rails a_1, a_2, a_3 supported by brackets a_4 attached to the rod a_5. The lower rail a_1 carries on its upper side small cups, or steps, usually made of glass, that form bearings for the skewers that hold the lower tier of bobbins in position, while on the under surface of the rail a_3 are placed holes into which the tops of the skewers project, thus holding the skewers, together with the bobbins, in position and at the same time allowing the bobbins to revolve freely as the roving is unwound. The rail a_3 also carries on its upper surface steps that serve as supports for the skewers of the top row of bobbins, while the under surface of the rail a_2 is provided with holes into which these skewers project. The upper surface of the rail a_3 provides a place for storing full bobbins, from which they may readily be taken when it is necessary to replace in the creel any bobbins that have become empty. The rails a_2, a_3 are adjustable, so that the distance between the rails can be changed to accommodate any length of bobbin. Fastened to each side of the rail a_3 are brackets a_6, a_7 that support the guide rods a_8; these rods serve to conduct the roving from the upper tier of bobbins to the drawing rolls, and thus prevent its coming in contact with the rail a_1.

5. Rolls.—The drawing rolls of a spinning frame are of the usual construction of drawing rolls, the top rolls being of the common leather-covered type. They have two bosses, either short or long bosses. The short boss, which is preferable for fine work, acts on only one end, while the long boss acts on two ends. The cap bars for these rolls are adjustable and so arranged that each one is independent of the others, being divided so that when the

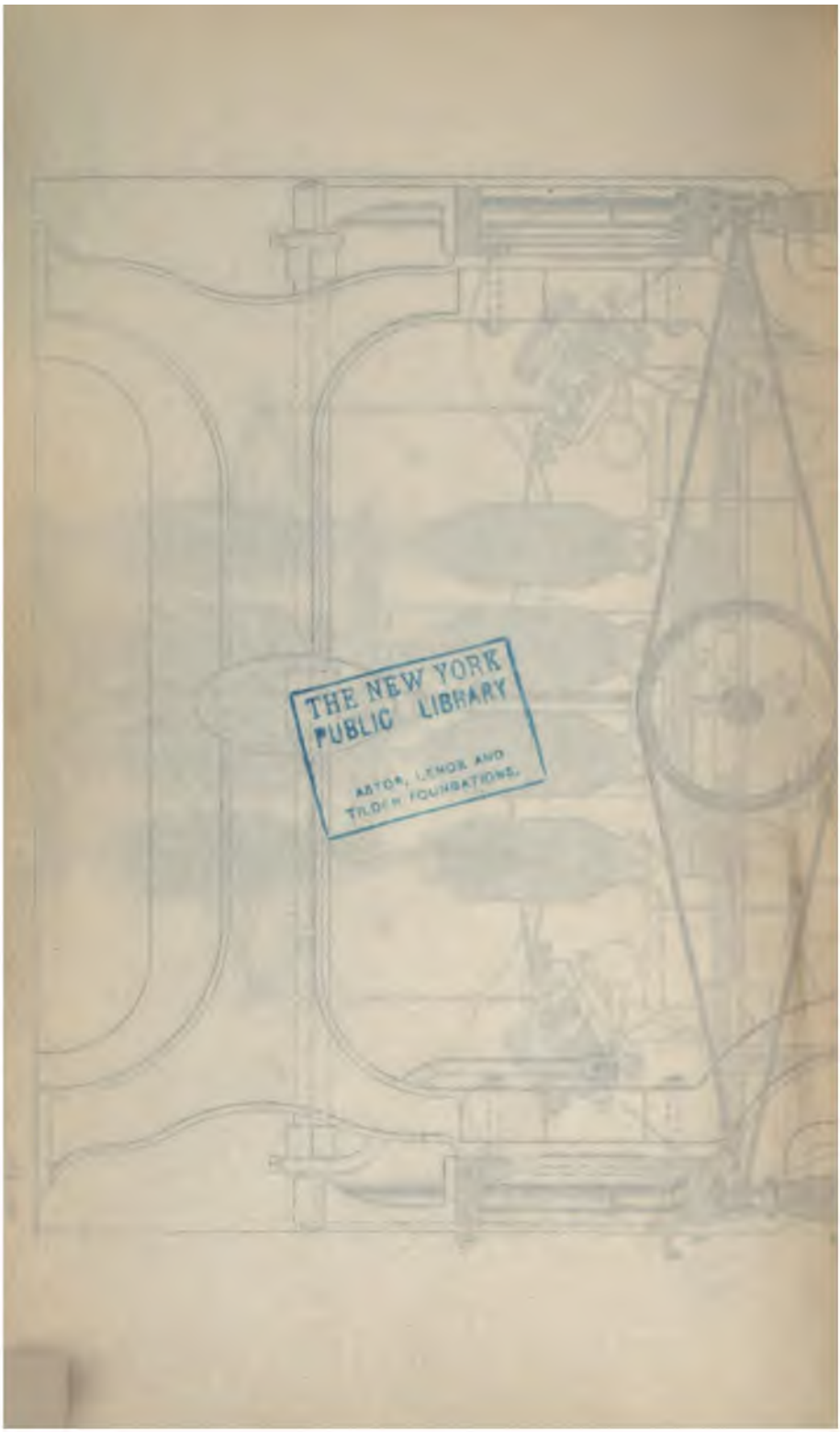

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FIG. 1


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bar is thrown back only its own particular set of rolls is affected. Sufficient space is also left between the two sections of the cap-bar finger over the roll bearings to allow

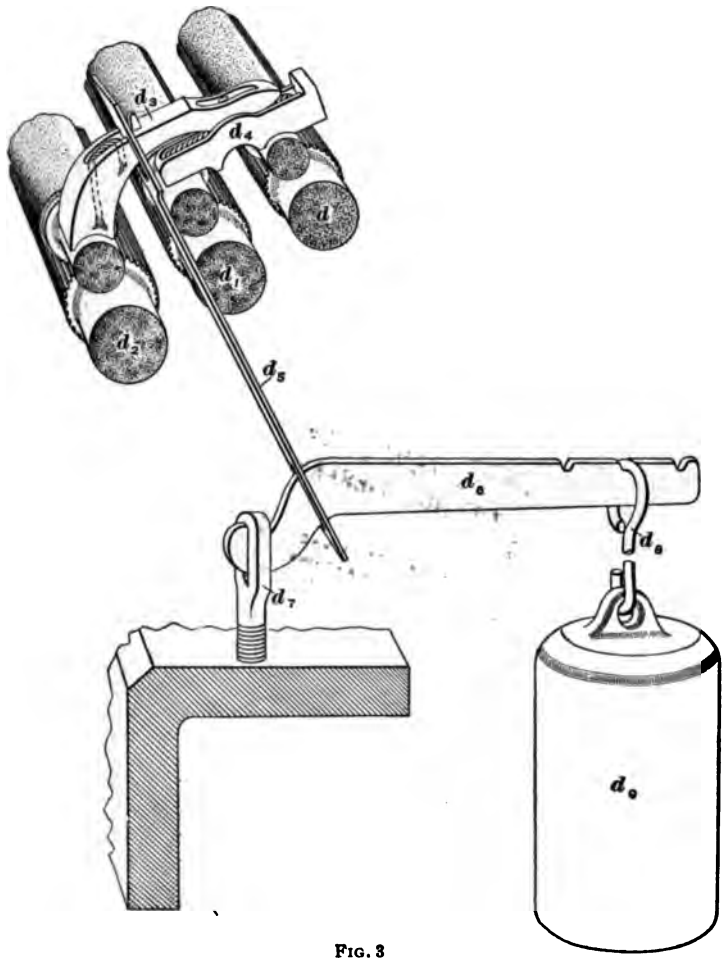


FIG. 3

the bottom rolls to be oiled. The bottom rolls are made of crucible steel, hardened throughout, and have either a short or a long boss, as may be required by the top rolls. The front bottom roll is usually 1 inch in diameter, while

the second and back bottom rolls are each about $\frac{7}{8}$ inch in diameter.

The rolls are weighted by means of the saddle and bridle system, as shown in Fig. 3. The saddles d_3, d_4, which are made of cast iron, are provided with oil chambers at the top, while holes run from these oil chambers to the roll bearings. Woolen yarns are drawn through these holes so that their ends just touch the bearings of the rolls, and since the yarn absorbs the oil and delivers it to the rolls as needed, this method provides a good means of constantly lubricating the bearings. The front saddle d_3 is made long enough to reach nearly to the back roll, and rests on a raised surface on the back saddle very near the back roll. The back saddle d_4 spans the back and middle rolls, and as the weight from the front saddle is applied nearer the back than the middle roll, the larger portion of the weight will be thrown on the former. The stirrup d_5, which is suspended from the saddle d_3, extends downwards between the front and middle rolls and has a weight lever d_6 passing through it at its lower end. The nose of the weight lever is attached to the roll beam by means of the lever screw d_7, while the opposite end carries a hook d_8 that supports the weight d_9. The upper surface of the weight lever d_6 is usually provided with two or three notches in any one of which the hook may rest, thus providing a ready means of altering the weight on the rolls.

Other systems of weighting the rolls are used, more especially the single-saddle system, which is adopted for fine yarns, and in which one saddle rests on the front and back rolls, while the middle roll has no weight on it whatever. Opinions vary as to which is the better method, even on the same class of work, as some overseers of spinning have been very successful with the single, while still others have been equally successful with the double system, even going to the extreme of using it on combed sea-island stock and spreading the rolls fully $1\frac{5}{8}$ inches or more.

The weight required on rolls depends on circumstances. Coarse work requires more than fine; double roving and long

draft, more than single roving and short draft. On ordinary numbers, say from 20s to 60s, with double roving and medium draft, a weight with sufficient leverage to give a pressure of 25 to 30 pounds on the rolls should be sufficient.

6. The path followed by the roving while passing through the rolls is not parallel with the upper surface of the roll beam, but forms an angle with it, the back rolls being farther from the roll beam than the front rolls. The object of placing the rolls in this position is to allow the twist as it is inserted in the yarn to run up nearly to the bite of the rolls instead of only to some point nearer the front on the outer circumference of the bottom front roll, as would be the case if the path which the roving follows through the

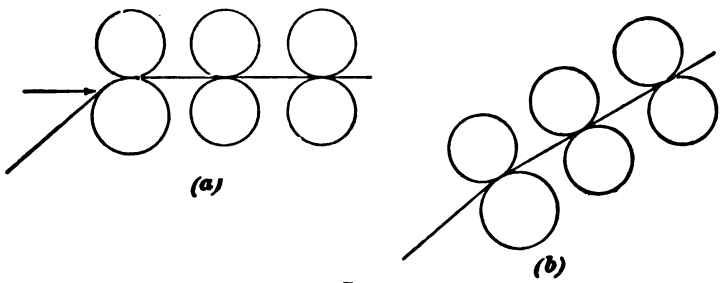


FIG. 4

rolls were parallel with the roll beam. Since the stock when delivered by the front rolls of the spinning frame has been drawn very fine and contains only a comparatively small number of fibers in a cross-section, it should be twisted immediately on leaving the front sets of rolls, in order that it may not be strained and the continuity of the strand destroyed. That the angle at which the rolls are set provides for this may be understood by referring to Fig. 4 (*a*) and (*b*). Fig. 4 (*a*) shows the position that the yarn would assume when delivered by rolls placed at the same distance from the roll beam, while Fig. 4 (*b*) shows the position that the yarn assumes when the front roll is lower than the back one. Referring to Fig. 4 (*a*), the yarn, as it is delivered by the rolls, is drawn over the surface of the bottom front roll for a

distance equal to between one-fourth and one-fifth of the entire circumference of this roll; consequently, the twist is

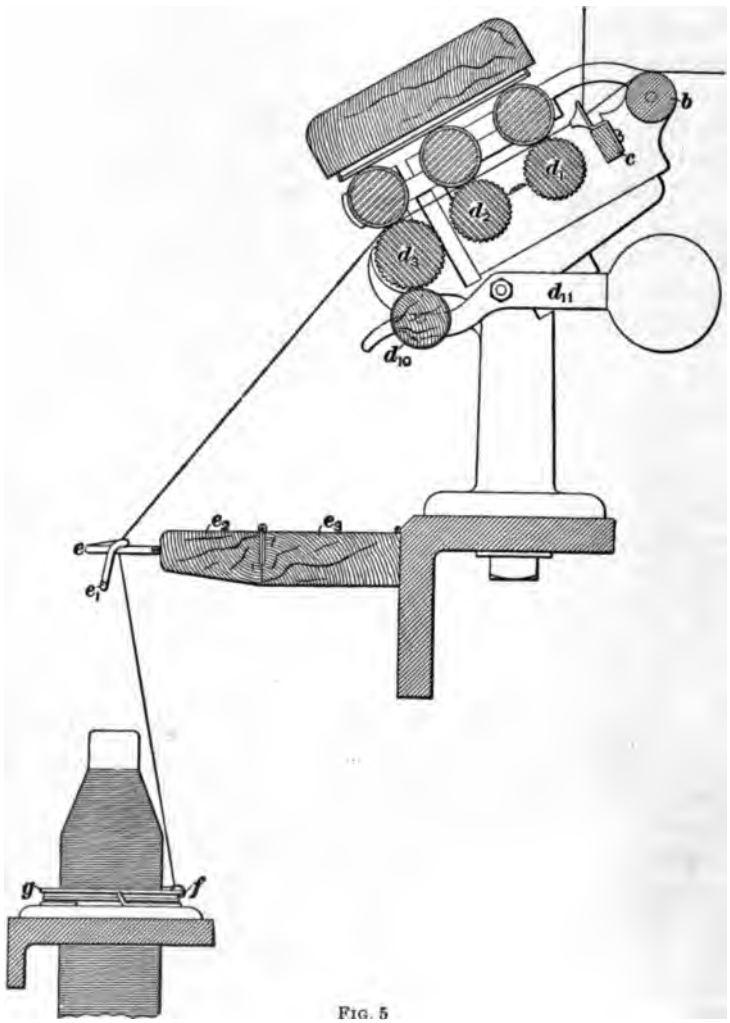


FIG. 5

not allowed to run up on the yarn any higher than the point at which it leaves the bottom roll, which is indicated by an arrow. Between the bite of the front rolls and the arrow

no twist is inserted, and as the fibers are subjected to considerable strain, they are very liable to be so pulled as to cause uneven yarn and frequent breakage. In Fig. 4 (*b*), the conditions are shown that actually exist in the ring spinning frame; owing to the inclination of the rolls, the yarn ceases to be in contact with the front roll almost at the same time that it leaves the bite of the rolls, and as there is no obstruction to the twist, it runs up nearly to the bite of the rolls.

The path of the yarn while passing through the rolls, that is, the working plane of the rolls, makes an angular inclination with a horizontal plane varying from 15° to 35°, commonly spoken of as the angle, or pitch, of the rolls. For frames spinning warp yarn, the angle is usually about 24°; while for frames spinning filling yarn, the usual angle is about 31°. With warp yarn, especially when considerable twist is being inserted, the angle at which the rolls are set does not very materially affect the yarn, but with filling yarn, especially if slack-twisted and spun from short-staple cotton, a considerable pitch is required. The position of the roll stands on the roll beam will also be found to affect the pitch of the rolls, since the farther back the stands are placed, the less pitch will be required in the rolls.

The stands for the rolls do not differ much from the ordinary construction of roll stands, with the exception that the bearings for the bottom rolls are so made that only the distance between the two front rolls can be changed, the second and back rolls having their bearings in one piece. The top clearers for the rolls are of the ordinary type, as shown in Fig. 5, while the bottom ones consist of round rolls d_{10}, covered with cloth, and rotated by frictional contact with the bottom rolls. At each end of the roll d_{10} is a small stud that fits into a notch in the end of a weighted lever d_{11} fulcrumed on a stud attached to the roll stand. Since the inner end of this lever is weighted, it forces upwards the end that carries the clearer, thus causing the clearer to be kept in contact with the bottom rolls. When an end breaks between the front rolls and the bobbins, it usually winds around this bottom clearer.

7. Guide Wires.—The two ends of roving that are passed through the same trumpet of the traverse rod at the back are twisted into one strand as they emerge from the front rolls and pass through a **guide wire** e, Fig. 5, that serves to give the yarn its correct position for winding on the bobbin. This guide wire consists of a curved piece of wire so arranged that it forms a circular hole, with the part of the circle where the yarn rests directly over the center of the spindle. The guide wire, or **thread guide** as it is often called, is so shaped that the yarn can be readily slipped into the hole but will not fly out; it also contains a notch e_1 known as a **kink arrester.** In case any obstruction prevents the yarn from winding on the bobbin, or if the traveler breaks, the yarn tends to fly out and become entangled with adjacent ends, thus breaking them down. To prevent this, the notch e_1, clearly shown in Fig. 6, is provided in the thread guide, which catches and cuts the yarn in case it is not winding on the bobbin properly, the loose end that comes from the rolls being wound around the bottom clearer. Each thread guide is screwed into a board e_3, Fig. 5, that is hinged to the board e_2; there is one board similar to e_2 for each thread guide, while the board e_2, for ordinary frames, is in two sections, each section extending half the length of the frame. The parts e_3, e_2 together are known as the **wire, or thread, board;** the part e_2 is capable of being thrown up out of the way irrespective of any other part, or the part e_2 may be thrown up and held by a catch, thus lifting all the thread guides attached to it out of position. This is necessary when removing the bobbins from the spindles.

Thread boards similar to that shown in Fig. 5 are not found to be entirely satisfactory. As there is no means of holding the thread guide positively in its correct position, it is liable to be turned slightly, which would throw the kink arrester out of position; or the thread guide may be given a complete turn, which would give it a wrong position with respect to the spindle. As the thread boards are made of wood, they are also affected by atmospheric conditions. To overcome these disadvantages, there has recently been placed

on the market a thread board that has the part similar to e, made of sheet steel, and has the thread guide securely locked in position. Referring to Fig. 6, that part of the thread guide e that projects into the thread board is made triangular in shape and is held by the binding nut e_4. To regulate the

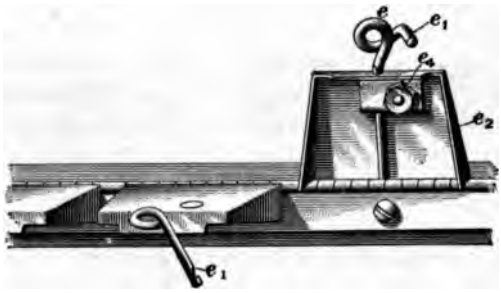


FIG. 6

position of the guide, the nut e_4 is loosened, when the guide may be moved to its correct position and then securely fastened. Since the part held by the nut is not circular in shape, the guide is prevented from turning; consequently, there is no liability of the kink arrester assuming an incorrect position.

8. Travelers.—From the thread guide the yarn passes to the **traveler** f, an enlarged view of which is given in Fig. 7; it is a steel clip, mounted on a ring g around which

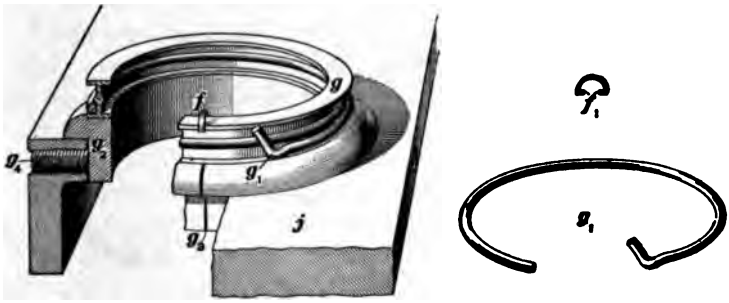


FIG. 7

it is free to revolve. The objects of the traveler are to guide the yarn to the bobbin and to provide a means of inserting twist in the yarn. When seeking to understand the manner

in which the traveler inserts twist in the yarn, it should be remembered that the bobbin on which the yarn is wound revolves at a high rate of speed and that this speed is constant throughout the building of the bobbin; also, that the front rolls deliver a constant length of yarn. Suppose, for illustration, that the bobbin is $\frac{3}{4}$ inch in diameter and that it makes 9,000 revolutions per minute; also, that the front rolls are delivering 471 inches of yarn in 1 minute. Then the tendency of the bobbin will be to wind on $\frac{3}{4} \times 3.1416 \times 9{,}000 = 21{,}206$ inches of yarn in the same time that only 471 inches is delivered. This will necessarily result in the yarn being broken between the front rolls and the bobbin. If, however, the yarn is passed through some such mechanism as the traveler that revolves with the bobbin, one of several results will take place: if the traveler makes the same number of revolutions per minute as the bobbin, no yarn will be wound on the bobbin; if the traveler makes a number of revolutions equal to the number of revolutions made by the bobbin less the number of revolutions required by the bobbin to take up the yarn delivered, the yarn will be wound on the bobbin and at the same time twist will be inserted in the yarn; if the traveler makes a less number of revolutions than that cited in the last instance, the yarn will be broken between the rolls and the bobbin.

Since the bobbin tends to wind on itself more yarn than is delivered, a tension is maintained in the yarn, and this tension being transmitted to the traveler causes the latter to revolve around the ring on which it is mounted. The traveler is made just sufficiently heavy to make it necessary that the yarn exert some strain before causing the traveler to revolve, and yet this strain is not great enough to break the yarn. If the front rolls deliver 471 inches per minute and the bobbin is $\frac{3}{4}$ inch in diameter, $471 \div (3.1416 \times \frac{3}{4}) = 200$, nearly, revolutions of the bobbin will be taken up in winding on this roving, and the traveler will make $9{,}000 - 200 = 8{,}800$ revolutions as it is carried around by the yarn. This will have exactly the same effect as if 471 inches of yarn was held firmly at one end and the other end twisted 8,800 times,

and will give 8,800 ÷ 471 = 18.683, turns per inch in the yarn. Hence, in ring spinning frames the following conditions exist: a bobbin revolving at a much higher rate of speed than is required to wind on the yarn delivered, and a traveler introduced that compensates for this excess speed by revolving the yarn at a slightly less speed than the bobbin. Since the diameter of a full bobbin exceeds that of an empty one, and since the bobbin makes the same number of revolutions per minute throughout the time that it is being filled, its circumferential speed must be greater when full than when empty; consequently, when the bobbin is nearly full, the traveler will be making more revolutions per minute and putting in more twist than when the bobbin is empty. The difference, however, is so slight that it is not considered in the construction of ring frames, and consequently there will be found no device on these machines for equalizing the twist in the yarn.

9. As travelers are often run at a speed of 50 miles an hour, day in and day out, they should be carefully made. Travelers are prepared from the highest grade steel wire drawn to the correct size and gauged to .001 inch. This wire is flattened, rolled, and annealed, after which it is cut and bent on automatic machines to the shape desired. The travelers are then hardened, tempered, scoured, and polished, each process requiring the greatest amount of skill and exactness. There are many kinds of travelers, but the two principal varieties are those having the points f_1, Fig. 7, rounded, as shown in this figure, and those having square points. The round-pointed traveler is generally preferred to the square-pointed traveler, which is the older form. Not only do travelers differ in the shape of the points, but also in the extent to which the wire is flattened, giving either a broad or a narrow back, and in the arch of the circle, some having a round back, while others are somewhat flattened. There is also a slight difference in the flange, or the turned-up portion, of the traveler. Travelers are placed in position by springing them on the rings; consequently, they should be

TABLE I

No. of Traveler	Weight of Ten Travelers Grains	No. of Traveler	Weight of Ten Travelers Grains	No. of Traveler	Weight o Ten Travelers Grains
53	118	26	64	1 –0	9
52	116	25	62	2 –0	8½
51	114	24	60	3 –0	8
50	112	23	58	4 –0	7½
49	110	22	56	5 –0	7
48	108	21	54	6 –0	6½
47	106	20	52	7 –0	6
46	104	19	50	7½–0	5¾
45	102	18	48	8 –0	5½
44	100	17	46	8½–0	5¼
43	98	16	44	9 –0	5
42	96	15	42	9½–0	4¾
41	94	14	39	10 –0	4½
40	92	13	36	10½–0	4¼
39	90	12	33	11 –0	4
38	88	11	30	12 –0	3¾
37	86	10	26	13 –0	3½
36	84	9	23	14 –0	3¼
35	82	8	20	15 –0	3
34	80	7	18	16 –0	2¾
33	78	6	16	17 –0	2½
32	76	5	14	18 –0	2¼
31	74	4	13	19 –0	2
30	72	3	12	20 –0	1¾
29	70	2	11	21 –0	1½
28	68	1	10	22 –0	1¼
27	66			23 –0	1

made with the correct size of flange for the ring used and with as small a distance between the points of the flanges as will go on the ring without unnecessary breakage. The tendency now is toward narrow-flanged rings, allowing a stronger traveler without increasing its weight.

The weight of travelers is indicated by a scale commencing with the heaviest, the travelers becoming lighter as the numbers are reduced to No. 1. In other words, taking No. 1 traveler as the standard with a weight of approximately 1 grain, travelers weighing more than 1 grain each are indicated by numbers from 1 higher; the higher the number, the heavier the traveler. Travelers lighter than 1 grain are indicated by whole numbers with 0 added from 1–0 to 23–0; the higher the number, the lighter the traveler. Table I shows the approximate weight, in grains, of ten travelers from No. 53 to No. 23–0, as made by one firm.

There are numerous other makes of travelers on the market, and although the same numbers are used for designating the size of the traveler, these numbers do not indicate the same weight in all makes.

10. Rings.—The rings on which the travelers are mounted are made of steel; they should be perfectly smooth and as nearly round as it is possible to make them, so that they will offer the least resistance to the traveler. The inside diameter of the rings determines their size, and will be found to vary with the different counts of yarn that are spun; for 28s warp yarn a ring $1\frac{7}{8}$ inches in diameter is often used.

Rings may contain one or two flanges, but it is more common to make them with two flanges, as shown in Fig. 7. They are supported on the frame by means of holders, which may be either of the cast-iron type, shown at g_1, Fig. 7, or of the plate type, shown in Fig. 8. In the cast-iron holder, a slot g_2, Fig. 7, is cut, which allows the holder to be sprung slightly and thus permits the lower flange of the ring to be forced into a recess in the upper part of the holder. The rail j, Fig. 7, of the spinning frame that supports these parts, known as the **ring rail**, contains holes

slightly larger in diameter than the outside diameter of that part of the holder that projects into them, the flange of the holder resting on the upper surface of the ring rail. Three screws similar to g_4, Fig. 7, two of which are at the front of the rail and one at the back, pass through the ring rail and serve to keep the holder in its correct position. In operation, it is very essential that the spindle, which passes through the ring, should be equally distant from every point on the inside of the ring. To provide a ready means of making any necessary adjustment, the parts are made as described, thus allowing the holder, together with the ring, to be moved within certain limits and held in the desired position by means of the screws.

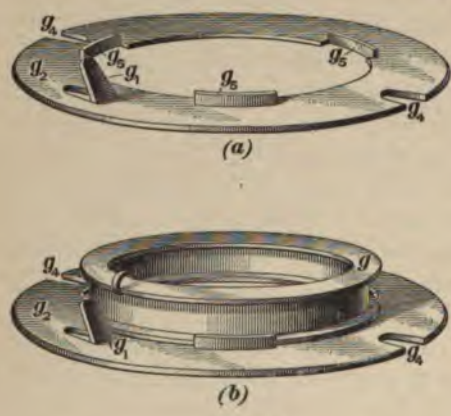


FIG. 8

The second type of ring holder, shown in Fig. 8, consists of a plate, Fig. 8 (*a*), that rests on the top of the ring rail, to which it is attached by small screws that pass through the slots g_4, thus allowing an adjustment similar to the cast-iron holder. Three small clips g_5 carried by the holder, and into which the lower flange of the ring is sprung, serve to hold the ring firmly in position, as shown in Fig. 8 (*b*). As it is necessary to have the ring rails perfectly level at all times, it is usually the custom to make them in sections instead of having one long rail for each side of the frame, thus avoiding any liability of the rail's sagging in the center.

11. Traveler Cleaner.—In order to remove the fly that naturally collects on the traveler from the yarn passing through it, there is attached to all makes of holders or rings

an appliance known as a **traveler cleaner.** When cast-iron holders are used, this generally consists of a bent piece of wire g_1, Fig. 7, sprung around the ring and having a projection that the traveler just escapes; thus, any fibers carried by the traveler are caught by this projection and removed. In the plate holder there is a lip g_1, Fig. 8, punched out, which projects high enough to catch any fly that may be carried by the traveler, thus serving the same purpose as the wire cleaner on the ring in the previous case.

12. Bobbins.—The bobbins on which the yarn is wound as it passes from the travelers are made of wood and are of two types—*warp bobbins* for warp yarn and *filling bobbins* for filling yarn. The bases of the bobbins set snugly either in a cup arrangement or on a bushing provided on the spindles and by this means receive motion; consequently, as the yarn passes directly to the bobbin from the traveler, it is the revolving of the bobbin that exerts the pull on the yarn necessary to set the traveler in motion. With the ordinary

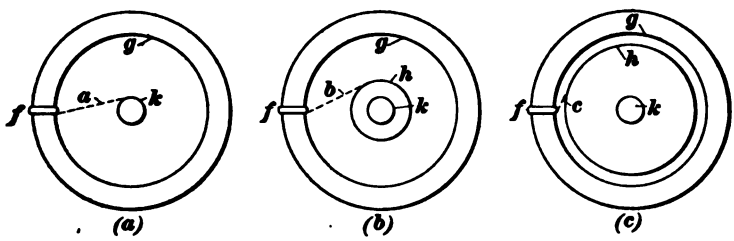


FIG. 9

ring and traveler, it is impossible to wind the yarn on a bare spindle, owing to the diameter of the spindle being so small that the yarn in passing to it from the traveler would pass almost directly to the center of the ring. This is more clearly shown in Fig. 9 (*a*), the circle *g* representing the inside of the ring and the circle *k* the outside of the spindle. The yarn, as represented by the line *a*, in being passed from the traveler *f* to the spindle *k* practically coincides with the radius of the ring; consequently, in this case the pull of the yarn tends to draw the traveler toward the center of the ring

instead of drawing it around the ring as is desired. If, however, a bobbin is placed on the spindle, as shown at *h*, Fig. 9 (*b*), and the yarn passed to the outside of the bobbin instead of to the spindle, the position that the yarn will assume may be represented by the line *b*, in which case the pull of the yarn will tend to revolve the traveler around the ring rather than pull it toward the center of the ring. Different sizes of bobbins are used on ring frames, but on account of the point just stated, it has been the custom in recent years to use larger rings and larger bobbins, a $\frac{7}{8}$-inch bobbin with a traverse of 7 inches being about right for 28s warp.

For the same reasons, a bobbin filled, or nearly filled, with yarn, being larger in diameter, will draw the traveler around with less tension on the yarn than with an empty bobbin; this is more clearly shown in Fig. 9 (*c*), where the direction of the yarn when winding on a full bobbin is shown by the line *c*; consequently, the effect of the traveler on the yarn is not the same throughout the filling of the bobbins. Although this difference is slight, it is a defect that has not as yet been successfully met by builders of ring frames.

13. Spindles.—The spindles form one of the most important parts of a ring spinning frame, and on them depends to a great extent the successful and economical operation of ring spinning frames. A special feature of a ring-frame spindle is that it is what is known as a *gravity spindle*, sometimes called a *top*, an *elastic*, or a *flexible* spindle, which indicates that it is allowed to find its own best center of rotation within certain limits, thus reducing or removing the liability of excessive vibration and wear. The older style of spindle was a rigid spindle, and this vibration and wear was a frequent occurrence when the spindle became slightly out of balance. There are numerous makes of ring-frame spindles on the market, and the purchaser of frames has his choice, since it is not necessary to adopt any one make of spindle with a particular make of frame.

Fig. 10 (*a*) is a perspective view of the *Whitin spindle*, while Fig. 10 (*b*) shows the spindle partly in section. It

consists of a long, slender, tapered steel shaft k known as the *spindle blade*, the lower part of which is in an inner casing k_1 supported on a solid pin k_3 milled into the bottom of the outer casing, or bolster, k_2. The inner casing is slightly smaller at the bottom than the inside of the outer casing, which allows the base of the blade a slight lateral movement and thus permits the spindle to find its own center of rotation within certain limits. Above the inner casing and attached to the spindle is a brass ring k_4 large enough in outside diameter to fit the inside of the outer casing and prevent the oil from rising and flowing over the top of the bolster. The spindle also carries a whorl k_5, which forms a pulley for the spindle band to pass around. It is by this means that the spindle receives its rotary motion. Above the whorl is a tapered steel bushing k_6 that fits the inside of the bobbin and thus causes the bobbin to revolve with the spindle. The oil is applied by means of a tube k_7 that forms a part of the outer casing. The oil percolates into the bolster case and thence, by means of two small holes k_8, into the inner casing and on to the spindle.

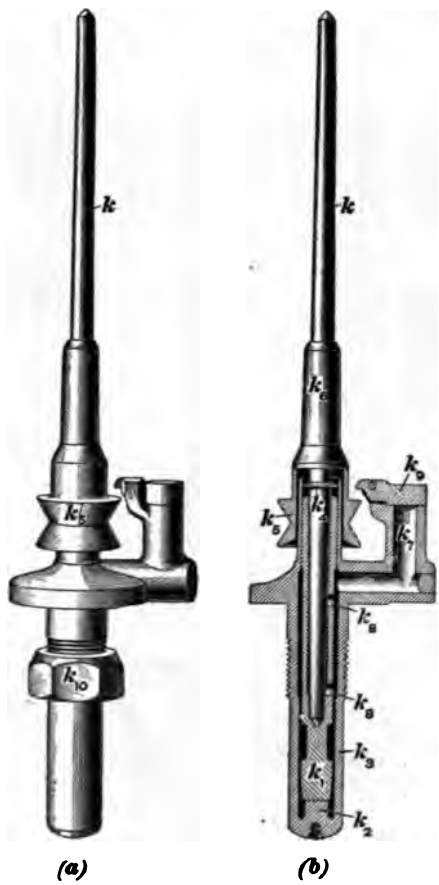


FIG. 10

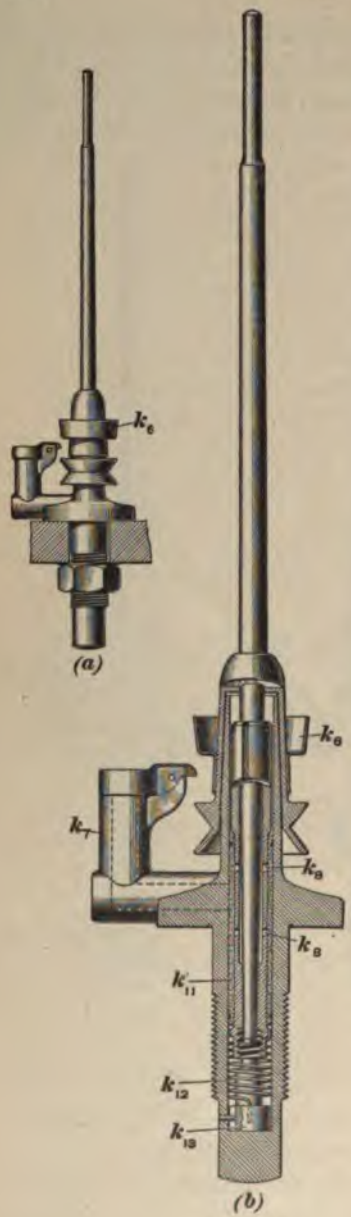


FIG. 11

14. The Woodmancy doffer guard and oil tube cap, which is applied to almost all modern spindles, consists of a cover, or cap, shown at k_{11}, Fig. 10, hinged to a projection or enlarged portion of the upright oil tube. The portion of the cap nearest the spindle projects beyond the hinge in the form of a hook and extends over the whorl for a short distance, in order to prevent the spindle blade from being removed from its position in its bolster when the machine is running. When it becomes necessary to remove the spindle blade, it may be done by simply raising the cap and uncovering the oil tube, which forces the hook downwards out of reach of the whorl of the spindle and thus leaves sufficient room for the spindle blade to be removed. The lower portion of

the bolster of the spindle passes through the spindle rail j_1, Fig. 2, and is held securely in position by the nut k_{10}. The *spindle rail* is a stiff iron rail running the entire length of the frame and securely attached to the sampsons j_3, Fig. 2.

15. Fig. 11 (*a*), (*b*), and (*c*) shows the *Draper spindle*, which is very largely used. Although this spindle somewhat resembles the Whitin, it differs in its details, principally in the construction of the inner casing. The parts of this inner casing are shown separately in Fig. 11 (*c*); k_1 is the main piece, a part of which is surrounded by packing k_{11}; the oil tube k_7 feeds the oil directly to this packing, which absorbs the oil and delivers it through the oil holes k_8 to the blade of the spindle. One end of the spring k_{12} projects into a slot in the lower part of k_1, while its other end passes through a hole in the screw k_{13}, which screws into k_1 and serves as a footstep for the spindle blade. The object of this construction is to relieve any binding action that may take place between the spindle blade and the inner casing, and is accomplished as follows: In case any binding takes place

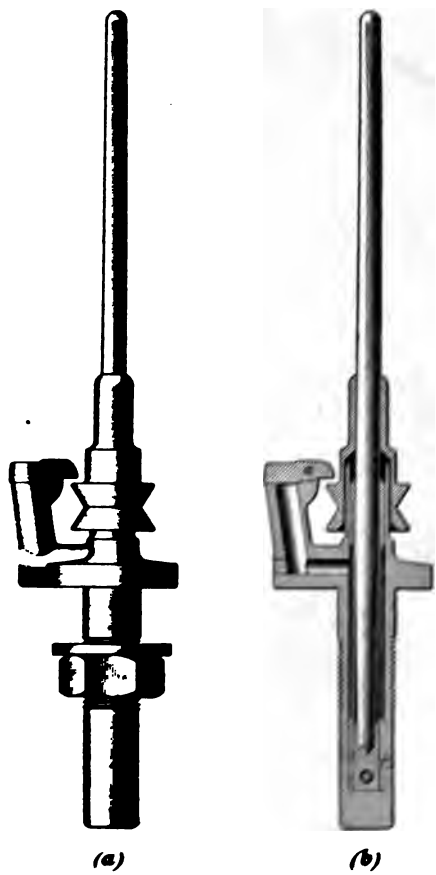


FIG. 12

between the spindle blade and k_1, the revolving of the blade will tend to turn k_1 down on screw k_{12}, thus compressing the spring k_{13}. As the slot shown in the screw k_{12}

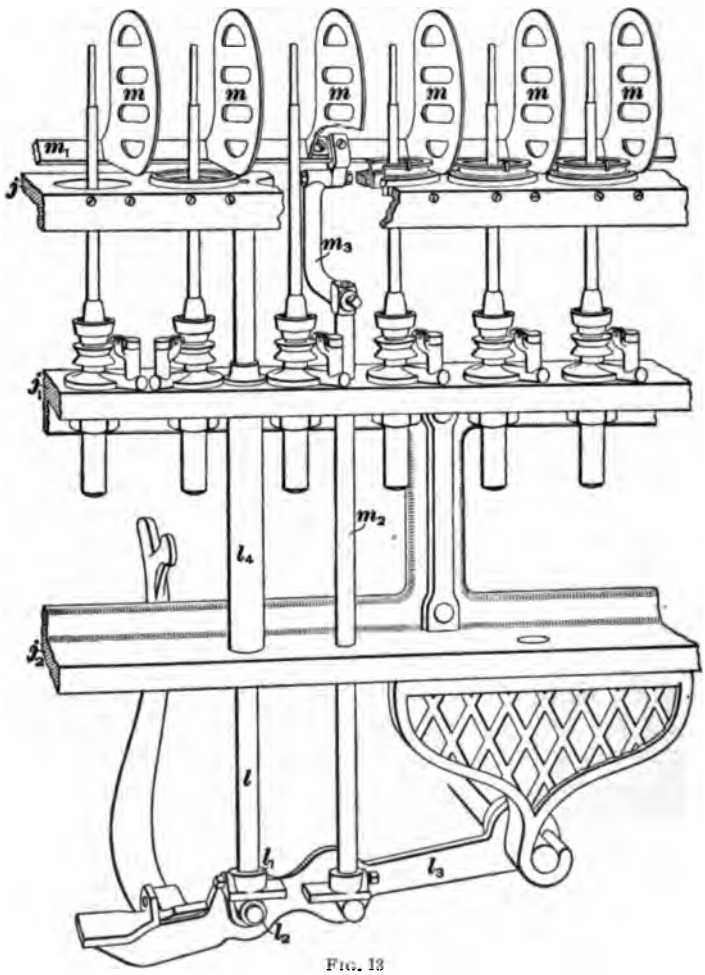


FIG. 13

engages with a pin in the base of the spindle, k_1 will occupy a lower position as it is turned downwards, although the spindle blade will remain at the same height, since k_{12} is

stationary. As the recess in k_1 in which the bottom of the spindle blade rests is larger at the top while the bottom of the spindle also has a corresponding taper, this downward motion of k_1 will tend to relieve the binding. On the other hand, should the spindle blade be fitting too loosely in the part k_1, the spring k_{1a} will tend to revolve k_1 in the opposite direction, forcing it upwards and thus fitting the blade more closely. In this make of spindle, the bobbin, instead of fitting tightly over the spindle blade, sets into a bobbin cup k_a and is thus rotated with the spindle.

Fig. 12 shows another spindle of this same type, known as the *McMullen spindle*. This spindle resembles to a large degree those described.

16. Lifter Rods.—In order to give the traversing motion to the ring rails, they are supported by the **lifter rods** l, Fig. 13. These rods, of which there are a number on each side of the frame, slide in suitable bushings in the spindle rail j_1 and also in another rail j_a, known as the *arch rail*, which is placed below the spindle rail, thus giving two steadying points to the lifter rods. The bottoms of the lifter rods rest in steps l_1 that are supported by bowls l_2 carried by a horizontal



FIG. 14

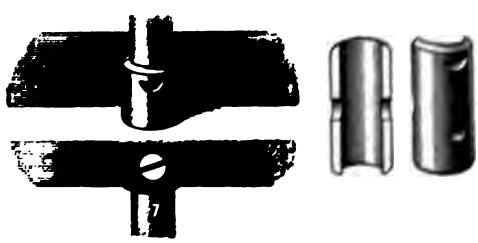


FIG. 15

arm l_3. The arm l_3 is given an up-and-down motion by a mechanism that will be described later, and acts as a lever to raise and lower the lifter rods. In order to prevent the accumulation of fly and dirt on the lifting rods, which would cause them to bind, a casing l_4, Fig. 13, that extends

the entire distance between the spindle and arch rails is provided on some frames. On other frames there is provided in place of the casing a device shown in Fig. 14. It consists of a bent piece of wire, the two ends being in the form of a ring and covered with a braided cord. These rings fit the lifter rod closely and thus prevent any foreign matter from passing into the bushings through which the rods pass. Sometimes the bushings held by both the spindle and arch rails are made in two vertical sections and are held in position by a screw, as shown in Fig. 15. With bushings made in this manner, it is possible to remove and clean them, while the frame is running.

17. Separators.—The traveler revolves around the ring at a very high speed (several thousand revolutions per minute), and as the yarn is held within a limited space by the thread guide at the top and by the traveler at the bottom, the loose yarn between these two points, rotating at so high a speed, tends to bulge out in the center on account of the centrifugal force generated, causing what is termed *ballooning*. This ballooning would result in the yarn from one spindle striking against the yarn from the next spindle, causing entanglement and breakage of ends, unless the gauge of the frames should be so large as to remove the possibility of the ends of yarn touching one another or some other means should be adopted to regulate the size of the balloon. To have a large space between the spindles causes an unnecessary expense in building so long a frame, as well as a waste of floor space; consequently, what is known as the **separator** is sometimes adopted and the space between spindles kept small.

There are various kinds of separators, but the one in use on the frame, shown in Fig. 13, is known as the *Whitin automatic separator*. It consists of perforated plates m, one between each two spindles, mounted on a rod m_1 in such a manner that they stand midway between the spindles. These plates are smooth, to avoid unnecessary friction on the ends that come in contact with them, and their effect is to keep the ballooning within certain limits by checking the

tendency to fly outwards generated in the yarn by the revolutions of the spindle. The central point of the balloon formed by the yarn varies as the rail moves up or down. For example, suppose that when the rail is at the bottom of its traverse the distance from the traveler to the thread guide is about $10\frac{1}{2}$ inches; then the balloon formed by the yarn will have its largest diameter at a point about 6 inches from the thread guide. On the other hand, as the ring rail moves up, the largest diameter of the balloon will be formed at a higher point; consequently, to have a separator operating to the best advantage it is necessary for it to move so as always to present the center of the plate as near as possible to the point where the largest diameter of the balloon is found. For all practical purposes it is generally considered sufficient to move the separator at the same speed and in the same direction as the ring rail. This, however, is not what actually takes place, for the reason that the rod m_1, Fig. 13, carrying the separator plates is actuated through m_2 by separate lifter rods m_3, which rest on levers l_3, and since the latter levers raise and lower the ring rail, the separators are raised and lowered at the same time, although not to an equal extent, as the rods m_2 are nearer the fulcrum of the levers l_3. It is necessary at certain times—for example, when removing the full bobbins—to throw the separators back so as not to interfere with the process of doffing; this is generally done by having the rod m_1 connected to the lifting rods m_2 by means of levers that hold the separators firmly in position between the spindles when working, but allow them to be thrown back, out of position, behind the spindles when not working.

Separators are an evil, but sometimes a necessary one. They are in the way of the spinner; they catch dirt and waste and distribute it on the bobbin; they interfere with the proper examination of the bobbins on the frame to see that they are all of the same height and in the proper place on the spindle; and they are an obstruction in removing the bobbins. On high-speeded and narrow-spaced frames, however, they are necessary.

18. Cylinder.—The spindles are driven by bands n_1, Fig. 2, that pass around the whorl of the spindle and also around a drum, or **cylinder** n, Fig. 2. The cylinder of a ring frame is usually between 6 and 8 inches in diameter, while the length varies according to the length of the frame; it is composed of very heavy tin and is made in sections, the end portions usually being constructed of cast iron. The cylinder is mounted on a shaft known as the *cylinder shaft*, which rests in adjustable bearings and is sufficiently long to project beyond the head, or driving end, of the frame and carry the customary tight and loose pulleys.

BUILDER MOTIONS

WHITIN BUILDER MOTION

WARP WIND

19. Spinning frames may produce either a warp-wind or a filling-wind bobbin; a section through a warp bobbin is shown in Fig. 16 (*a*). In winding the yarn on such a bobbin it is wound in layers that extend nearly the entire length of

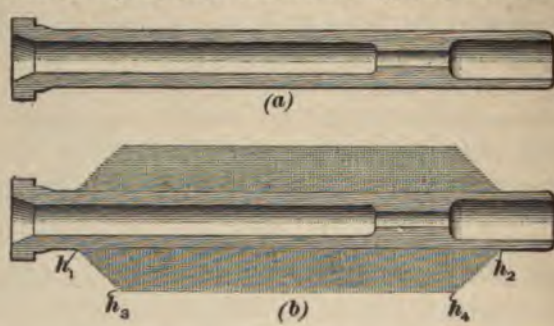


FIG. 16

the bobbin, each succeeding layer being slightly shorter than the preceding, which gives to the full bobbin a taper at both ends. Thus, referring to Fig. 16 (*b*), which shows a section through a full bobbin having a warp wind, the first layer

extends nearly the entire length of the bobbin, or from h_1 to h_2. The next layer is slightly shorter than this first layer, and each succeeding layer is slightly shorter than the preceding, until the last layer is placed on the bobbin, which extends from h_1 to h_2. Thus, in a warp-wind bobbin these two points must be considered: The yarn must be traversed from one end of the bobbin to the other, while with each succeeding layer the length of the traverse must be slightly shortened. The mechanism adopted to produce these results is known as the **builder motion**, and is illustrated in Figs. 17 and 18, which show a **Whitin builder motion.**

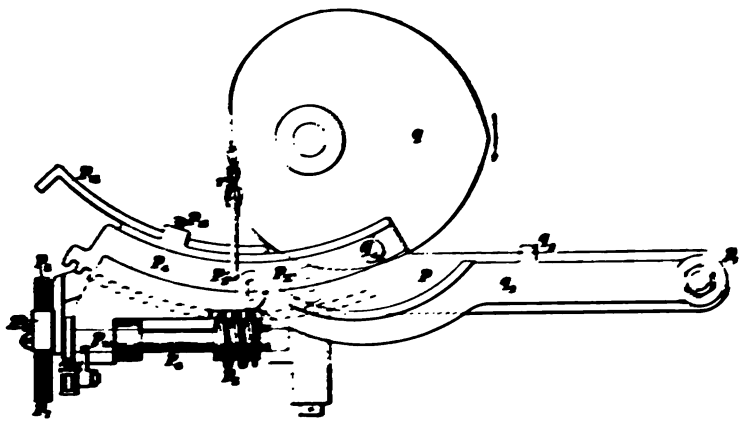
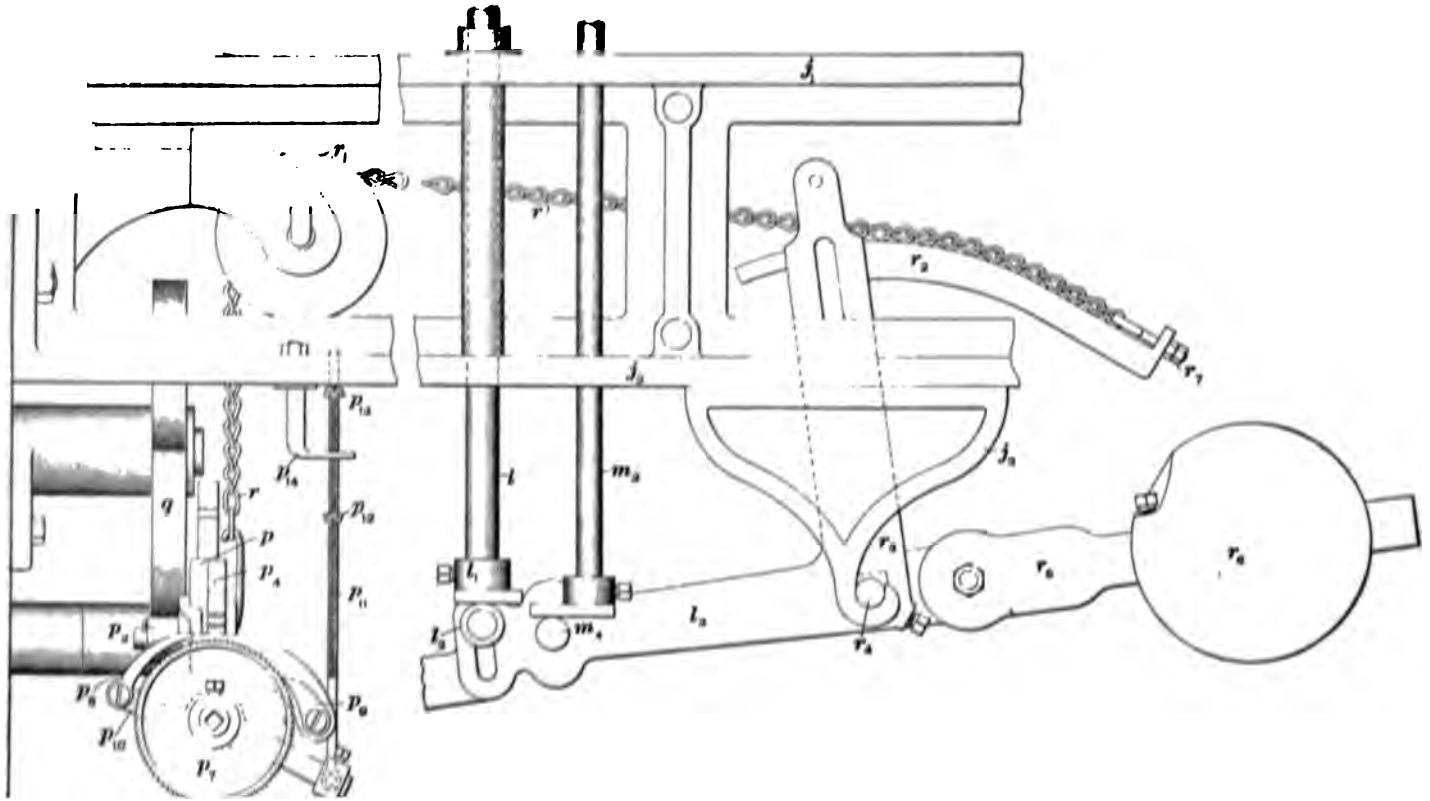


FIG. 17

20. Referring to Fig. 17, the arm p that is pivoted on a stud at the point p_1 carries a cam-stud p_2 that is operated by the cam q. This arm is free to move on the stud to which it is pivoted and supports the several parts. The chain r, which is connected at the point p_3, passes up over a pulley r_1, Fig. 18, and is connected to a chain r_2, attached to an upright arm r_3. This upright arm is connected to a rod r_4, that runs transversely across the frame and is supported by brackets j_1 fixed to the rail j. The horizontal arm j_2 is likewise connected to the rod r_4 and supports the latter rod. An arm r_5, that is also connected to the rod r_4, carries a weight r_6 that tends to swing the upright arm r_3 to the right


r_1
r
j_1
r_2
r_3
j_2
p_{13}
p_{14}
p_{12}
q
r
p
p_4
p_{11}
p_3
p_5
p_{10}
p_9
p_7
l
m_2
l_1
l_2
m_1
l_3
j_3
r_5
r_4
r_6
r_7

As was explained, the lifter rods l support the ring rail, which carries the rings on which are mounted the travelers that guide the yarn to the bobbins; consequently, if the lifter rods are raised and lowered, the ring rail will move with them and give a traverse to the yarn on the bobbins.

Dealing first with the traverse motion and ignoring the shortening of the traverse, as the cam q, Figs. 17 and 18, revolves and acts on the cam-bowl p_3, it will force the arm p down, taking with it the chain r, which, by acting on the quadrant r_3, will swing the arm r_2 to the left, turn the rod r_4 and lift the weight r_5. Lifting the weight r_5 allows the lifter rod to drop, owing to its own weight and that of the ring rail that rests on it. During this action the rings, together with the travelers, are moving from the top to the bottom of the bobbin, giving the desired traverse in this direction. As the cam q, Fig. 17, continues to revolve, the point at which it comes in contact with the cam-bowl will commence to move nearer the center of the cam, thus allowing the arm p to rise through the action of the weight r_5 on the arm r_2. This weight is made sufficiently heavy to overbalance the weight of the ring rail and the lifter rod; consequently, as the chain is slackened by the action of the cam, the weight forces the lifter rods together with the ring rail up, thus causing the rings, together with the travelers, to move from the bottom to the top of the bobbins and give the necessary traverse in this direction. It is in this manner that the traverse of the yarn on the bobbin is obtained.

21. Dealing next with the method of shortening the traverse with each succeeding layer, Fig. 17 shows that the chain r instead of being passed directly to the arm p is connected to a rack p_4 that is supported in grooves cast in the arm p. On the lower side of this rack are teeth working in the worm p_5, which is on the shaft p_6 supported by the arm p. On the end of this shaft is a ratchet gear p_7, shown more clearly in Fig. 18. Working in the teeth of this ratchet gear is a pawl p_8 mounted on an arm p_{10} that is supported by the shaft p_6, Fig. 17, and has connected to its other end a threaded

rod p_{11}, Fig. 18, carrying two pairs of setnuts p_{12}, p_{13}. The rod p_{11} passes through a hole in the casting p_{14} secured to the rail j_3. Another part that is supported by the arm p is p_{15}, Fig. 17, which simply serves to regulate the distance to which the rack p_4 may be moved to the left, and may be placed in any desired position after loosening the setscrew p_{16}.

The action of this mechanism is as follows: When the first layer is being placed on the bobbin, the rack p_4 is as far to the left as p_{15} will allow it to be moved. In this position the chain r is as far from the fulcrum of the arm p as it can go, and consequently the ring rail will be receiving its greatest traverse. With each downward motion of the arm p, caused by the action of the cam q on the cam-bowl p_2, the rod p_{11}, Fig. 18, in being moved down with the arm will bring the setnuts p_{13} against the casting p_{14}, which will prevent the rod p_{11} from moving any farther in this direction. As the arm p has not completed its downward motion at this point, it will necessarily cause the pawl p_5 to turn the ratchet gear p_7 a certain number of teeth, this number depending on the position of the setnuts p_{13} on the rod p_{11}. As the ratchet gear p_7 is turned, it gives motion to the shaft p_6, Fig. 17, that carries the worm p_8. This worm, engaging with the teeth on the rack p_4, will cause it to move to the right, thus bringing the point at which the chain r is fastened nearer the fulcrum of the arm p and consequently shortening the traverse that the arm gives to the ring rail.

During the next motion of the ring rail, that is, when the weight r_5, Fig. 18, is forcing the lifter rod l up and bringing the quadrant r_3 to its former position, the arm p in rising will bring with it the threaded rod p_{11}. During this motion the other pair of setnuts p_{12} will come in contact with the casting p_{14}, and the pawl p_5 will be moved back to the right, when it is again in its correct position to engage with the teeth of the ratchet gear at the next downward motion of the arm p. The pawl p_5 is simply a stop-pawl that serves to hold the ratchet gear in its position as the pawl p_5 is moved to the right. The number of teeth on the ratchet gear that are taken up with each downward motion of the arm p is

regulated by the distance between the setnuts p_{12}, p_{13}, which is regulated to accommodate any counts of yarn. The ratchet gear may also be changed in case it is desired to make any very great alterations.

FILLING WIND

22. A section through a filling bobbin is shown in Fig. 19 (*a*). When winding the yarn on such a bobbin each layer instead of extending from one end of the bobbin to the other extends only a short distance, while each succeeding layer is moved slightly higher on the bobbin. Thus, referring to Fig. 19 (*b*), which shows a section through a bobbin filled with yarn, the first layer extends from h_1 to h_2, the next layer has exactly the same length of traverse but starts slightly higher on the bobbin than the point h_1. Each succeeding layer moves correspondingly higher on the bobbin

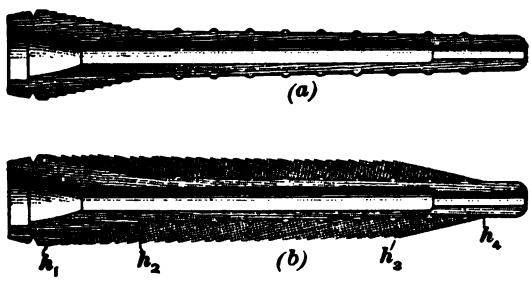


FIG. 19

until the last layer is wound on, which extends from h_3 to h_4. In a filling-wind motion, consequently, these two points must be taken into consideration: the traverse must be considerably shorter than that found on the warp-wind; while, although the length of the traverse is not changed with each succeeding layer, the position of the layer on the bobbin must be slightly higher than that of the preceding layer.

The distance from h_3 to h_4 is spoken of as the *traverse*, or *chase;* the part h_3 as the *shoulder;* and the part h_4, as the *nose*. Owing to the manner in which the yarn is wound on such a bobbin, and also the fact that these bobbins are usually

unwound during weaving, the yarn being pulled from the nose of the bobbin, it is necessary in some manner to bind each coil so that the yarn will not pull off in a bunch, which is known as *slubbing off at the nose.* The manner in which this is accomplished on spinning frames is to have the coils of one layer close to one another while the coils of the next layer are widely separated. Suppose, for example, that the ring rail when moving down travels slowly; then the coils from the top of the traverse to the bottom will lie close together, while if the rail in moving up has a quick motion, the coils will be open and will tend to hold the yarn previously wound. This system is known as *binding from the shoulder to the nose,* since the binding coil traverses from the largest to the smallest diameter. If, however, the ring rail should have its slow motion when moving up and its quick motion when moving down, this would be *binding from the nose to the shoulder.* Both of these methods are adopted on ring frames, and makers of each claim advantages.

COMBINATION BUILDERS

23. Builder motions may be made for a warp wind alone, for a filling wind alone, or may be made so that with only slight changes either wind may be produced; in the latter case the motion is known as a **combination builder.** The builder motion that is suitable for a warp wind only is practically the same as a combination builder with the parts used for filling wind omitted, while a builder motion that is suitable for a filling wind only is practically the same as a combination builder with the mechanisms for producing a warp wind omitted. The builder shown in Figs. 17 and 18 is a combination builder, and when changing from a warp wind to a filling wind, only slight alterations are necessary. These are as follows: (1) The cam q, Fig. 17, which is known as a warp-wind cam, is replaced by a filling-wind cam q_1, Fig. 20; (2) the chain r, which was previously connected to the rack p_4, is now connected to the arm q_2, which, when producing a warp wind, has no function to perform, but is

simply supported by the arm p by means of the overhanging projection q_3. This arm when connected with the chain is raised until it comes in contact with the stud q_4 on the rack p_4. When this change is made, it is necessary to shorten the chain r somewhat; this is accomplished by means of the nuts r_7, Fig. 18, which connect the chain to the quadrant r_2. Owing to the shape of the cam q_1, Fig. 20, the extent of the traverse of the ring rail is considerably shortened; also, the arm p is given a slow motion as it moves downwards, while its motion upwards will be slightly accelerated. Thus, with this builder motion the binding of the yarn will take place

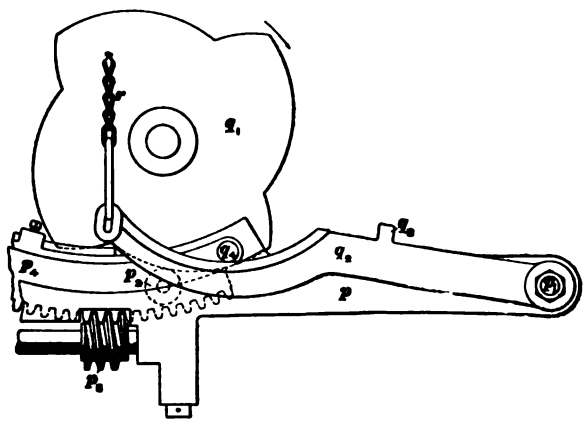


FIG. 20

when the rail is moving up, or, in other words, from the shoulder to the nose of the bobbin.

The traversing of the yarn on the bobbin with a filling wind is similar to that of a warp wind; that is, the revolving of the cam alternately forces the arm p down and allows it to be raised by means of the weights. The change in position of each coil of yarn on the bobbin, however, is obtained in a somewhat different manner than the varying distance of the traverse in a warp wind and will need some description. Referring to Figs. 17, 18, and 20, the action of the pawl on the ratchet gear p_7, Fig. 18, is exactly the same in the filling wind as in the warp wind; consequently, with

each downward motion of the arm p the ratchet gear p_7 will be turned a certain number of teeth, which, by turning the worm p_5, will force the rack p_4 to the right. As the arm q_2, Fig. 20, to which the chain is connected, is in contact with the stud q_4 carried by the rack p_4, the point of contact between the stud and the arm q_2 will be moved to the right together with the rack p_4. The face of the arm q_2 on which the stud works, also the groove in which the rack p_4 slides, is so shaped that as the stud is moved to the right, the arm q_2 is allowed to assume a somewhat higher position; consequently, the ring rail also assumes a higher position, due to the weight r_6, Fig. 18, forcing the lifter rod l upwards as the chain is slackened. Thus, although the length of the traverse is not altered, since the position at which the chain is connected to the arm q_2, Fig. 20, bears the same relation to the fulcrum p_1 of this arm during the entire building of the bobbin, each succeeding layer of yarn will be somewhat higher on the bobbin, owing to the point at which the chain r is connected to the arm q_2 being raised at each succeeding downward motion of the ring rail. With both the filling- and warp-wind motions, the rack p_4 has to be moved to the left after the bobbins have been filled, in order to obtain the correct position for starting a new set of bobbins. This is accomplished by fitting a handle to the ratchet gear p_7, Fig. 18, and turning the ratchet until the worm p_5, Figs. 17 and 18, has moved the rack p_4 to its correct position, when the different parts will be in position to place the first layer of yarn on the bobbins.

HOWARD AND BULLOUGH BUILDER MOTION

WARP WIND

24. The **Howard and Bullough builder motion** is illustrated in Figs. 21, 22, and 23. This motion is also a combination builder and may be readily changed from warp to filling wind or vice versa; the cam q acts on the cam-bowl p_3 in the case of winding warp bobbins, while for filling bobbins

the cam q_1 is in contact with p_2. The cam-bowl p_8 is supported by an arm p that is supported by the stud p_1 and has a bearing point on the screw s_1. The casting s that

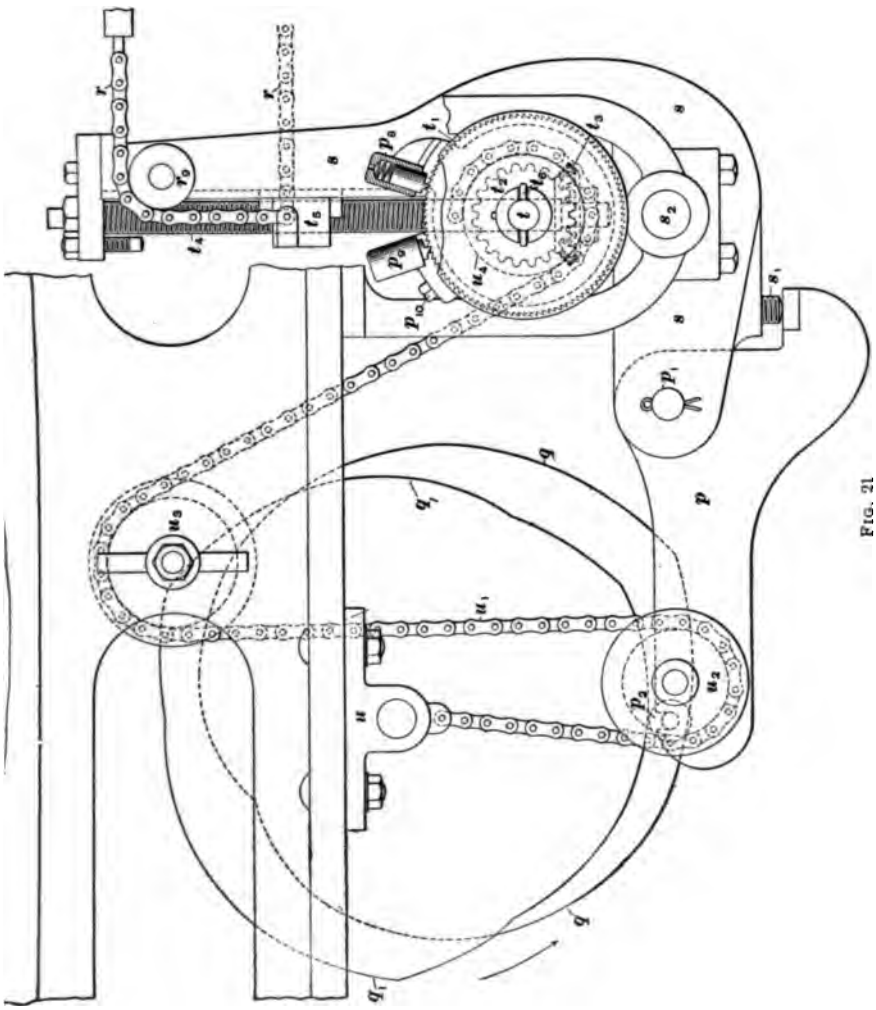


FIG. 21

swings on the shaft s_2 carries the stud p_1; consequently, the horizontal arm of the casting s, together with the arm p, acts as one lever to throw the upper part of s to the left as the

cam forces the arm p down. The object of connecting these parts in this manner is to give an adjusting point to the casting s, the screw s_1 governing the exact position that the different parts assume. Supported by the shaft t is a ratchet gear t_1, shown in Figs. 21 and 22, while at its other end this shaft carries a bevel gear t_2 gearing into another bevel gear t_3 on a screw t_4 that is supported by the casting s. Working on the screw t_4 and having a bearing against the upright arm of the casting s is a block t_5 that has attached to it the chain r, which is connected to the rod r_6, Fig. 23. This rod is connected to the upright arm r_3 fastened to the shaft r_4, which runs transversely across the machine and carries an arm l_3 that supports the lifting rod l_4. The shaft r_4 also carries an arm supporting weights similar to the weights on the builder motion previously described. Connected to the casting u, Fig. 21, is a chain u_1 that passes around the pulleys u_2, u_3 and is attached to a pulley u_4, Fig. 22, that is on a sleeve with the disk u_5 that supports the pawl p_6.

25. The action of this motion for warp wind is as follows, considering first the traversing of the ring rail without any reference to the shortening of the traverse. As the cam q revolves, during a part of its revolution it lowers the arm p by pressing down on the cam-bowl p_2, although this is not shown in Fig. 21, as the cam-bowl is in contact with the filling cam q_1. The lowering of the arm p swings the entire upper part of the casting s, together with its several parts, to the left, which, bringing with it the chain r, swings the upright arm r_3, Fig. 23, to the left, raising the arm l_5 and thus lifting the lifting rod. During the rest of the revolution of the cam the bowl is working from the toe to the heel; consequently, weights that are attached to the shafts r_4, s_5 swing the upper part of the bracket s to the right, slackening the chain r and allowing the ring rail together with the lifting rods to drop by their own weight.

Considering next the method adopted to shorten the traverse of each succeeding layer of yarn placed on the bobbin; when the mechanism is producing a warp wind,

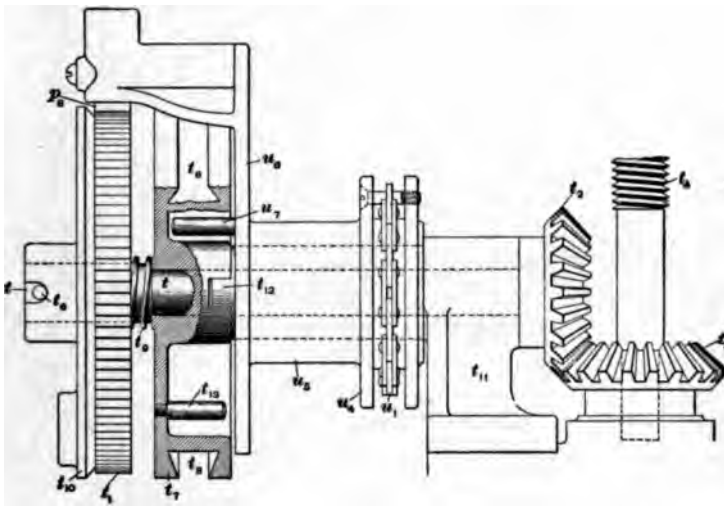


FIG 22

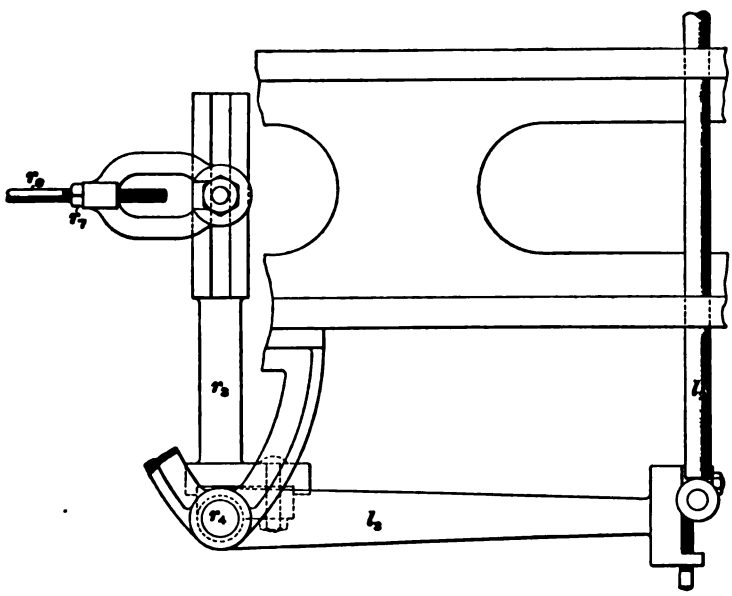


FIG. 23

the chain r, which is attached to the block t_8 is in the position shown by the dotted lines in Fig. 21. When the ring rail is receiving its greatest lift, this chain should be exactly horizontal. With each downward motion of the arm p, the pulley u_3, which is attached to this arm, forces the chain u_1 down, causing the pulley u_4, Fig. 22, to make a partial revolution. The pulley u_4 is on a sleeve u_5, together with the disk plate u_6 to which the pawl p_6 is attached; consequently, as this pulley revolves it causes the pawl p_6 to engage with the teeth of the ratchet gear and turn this gear a certain number of teeth. This action being communicated to the shaft t causes the bevel gear t_3 to turn the bevel gear t_4 together with the screw t_5. With each motion of the screw t_5, the block t_8 is moved downwards, causing the chain r to assume a slightly lower position, which results in the ring rail receiving a shorter traverse.

The stand t_{11} carries a sleeve that projects through the collar u_6 and forms a bearing for the shaft t. In the end of the sleeve nearest the plate t_7 are two lugs, one of which is shown at t_{12}, that project into cut-outs in t_7 and thus serve to hold the plate securely in position. Some such arrangement as this is necessary, since the plate is loose on the shaft t and it is not desired that this plate should revolve with the shaft. A spiral spring, one end of which is attached to the stud t_{13} on the plate t_7, while the other end is attached to the stud u_7 on the disk u_6, serves to bring the pawl p_6 back into position as the arm p is raised. The pawl p_6, Fig. 21, is supported by a casting that carries a flange fitting into the recess t_6 of the plate t_7, Fig. 22, and may be moved to any desired position on this plate by means of loosening the setscrew p_{10}, Fig. 21. This pawl, in addition to acting as a stop-pawl for the ratchet gear t_1, regulates the number of teeth that the pawl p_6 takes up on the ratchet gear with each downward motion of the lever p, since the pawl p_6, when it is brought back by the spiral spring as the lever p rises, comes in contact with the pawl p_9, which prevents its moving any farther in this direction; if the pawl p_6 is placed in such a position that the pawl p_6 comes

in contact with it before the lever p has assumed its highest position, the pawl p_8 will take up less teeth on the ratchet gear t_1.

The ratchet gear t_1 is key-seated to the shaft t in such a manner that it may be slid along the shaft but must revolve with the shaft. It is kept in position by means of the spring t_9 pressing the hub of the flange t_{10} against the pin t_8. When the bobbins have been filled and it is desired to turn the shaft t in order to bring the block t_8 back into its correct position for starting a new set of bobbins, this may be done by pushing the ratchet gear t_1 and flange t_{10}, Fig. 22, to the right until the pawls p_8, p_8 are forced to the outer edge of t_{10}, which is fast to the gear t_1, thus bringing them out of contact with the ratchet gear t_1. When in this position a handle that is inserted in the flange t_{10} is used to revolve the ratchet, together with the shaft t, until the block t_8 is brought into its desired position. The pawls p_8, p_8 are kept in contact with the ratchet t_1 by means of springs, the one for p_8 being shown in Fig. 21, and when the ratchet gear t_1 is moved in, the flange t_{10} readily compresses the springs in the pawls sufficiently to allow the pawls to rest on the outer rim of the flange.

FILLING WIND

26. When changing to a filling wind with this motion, the cam-bowl is moved to one side until it is in contact with the cam q_1. The chain r, instead of passing horizontally to the rod r_8, Fig. 23, is passed over the pulley r_9, as shown by the full lines in Fig. 21. By this means, as the block t_8 is brought down by the revolving of the screw t_4, the chain will force the ring rail to a higher position as each coil is placed on the bobbin, although the length of the traverse will not be altered. In changing the chain from the position it assumes with the warp-wind motion to the one that it assumes in a filling wind, it may be necessary to alter its length. This may be done by loosening the nut r_7, Fig. 23, and turning the rod r_8 until the correct length is obtained, when the setnut may be tightened.

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In all makes of ring frames there are along the length of the frame several lifter rods. These rods are arranged in

TABLE II

Number of Spindles	Gauge											
	3½		3¼		3		2¾		2⅝		2½	
	Length of Frame											
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
120	19	6	18	3	17							
132	21	3	19	10½	18	6						
144	23		21	6	20							
156	24	9	23	1½	21	6						
168	26	6	24	9	23							
180	28	3	26	4½	24	6						
192	30		28		26							
204	31	9	29	7½	27	6						
216	33	6	31	3	29							
228	35	3	32	10½	30	6						
112							14	10	14	3	13	8
128							16	8	16		15	4
144							18	6	17	9	17	
160							20	4	19	6	18	8
176							22	2	21	3	20	4
192							24		23		22	
208							25	10	24	9	23	8
224							27	8	26	6	25	4
240							29	6	28	3	27	
256							31	4	30		28	8
272							33	2	31	9	30	4
288							35		33	6	32	
304							36	10	35	3	33	8

pairs, one rod of the pair on each side of the frame, and each rod is operated by a separate arm similar to the arm *l*, shown

in various illustrations. In order to operate all the lifter rods throughout the length of the frame, there are a number of shafts similar to r_4 running transversely across the machine. Each shaft carries an upright arm similar to r_3 while the arms are connected to one another by means of a rod; consequently, as the arm nearest the builder motion, which is the one directly acted on, is moved back and forth it will in turn impart the same motion to the other upright arms.

DIMENSIONS

27. The term *gauge* used in connection with spinning frames implies the distance from the center of one spindle to the center of the next spindle in the same row. The standard gauges for the frames described are $3\frac{1}{2}$, $3\frac{1}{4}$, 3, $2\frac{3}{4}$, $2\frac{5}{8}$, and $2\frac{1}{2}$ inches.

The length of the frames varies according to the gauge and the number of spindles. Frames are usually built with from 160 to 288 spindles, although they may be built with a greater or less number. In speaking of the number of spindles of a ring frame, both sides are included; consequently, a frame of 288 spindles would have 144 spindles on a side. The width of the frames varies somewhat; the two standard widths for the frames described are 36 and 39 inches, respectively. Table II gives the standard length of these frames, together with the gauge of each.

RING FRAMES

(PART 2)

MANAGEMENT OF SPINNING ROOMS

CALCULATIONS FOR RING FRAMES

DRIVE

1. The driving of a spinning frame is accomplished through ordinary tight and loose pulleys that are mounted on the cylinder shaft w shown in Fig. 1, which also shows the gearing of a spinning frame. The loose pulley is usually made slightly smaller in diameter than the tight pulley, in order to relieve the strain on the belt when not driving the frame. To facilitate shifting the belt from one pulley to the other, the face of the tight pulley is beveled on the side next to the loose pulley. The shaft w also carries the cylinder n that drives the spindles through the bands n_1. Situated at the driving end of the machine and mounted on the shaft w is the gear w_1 of 42 teeth driving the gear w_2 that is compounded with the gear w_3; this gear drives the gear w_4 compounded with the gear w_5, which through the carrier w_6 drives the gear w_7 on the front roll shaft w_8. Since on spinning frames there are two sets of drawing rolls, one on each side of the machine, it is necessary to introduce gearing that will drive the front roll shaft on the side of the frame opposite that where the shaft w_8 is located. This is accomplished by having the gear w_9, in addition to meshing with w_7, drive the

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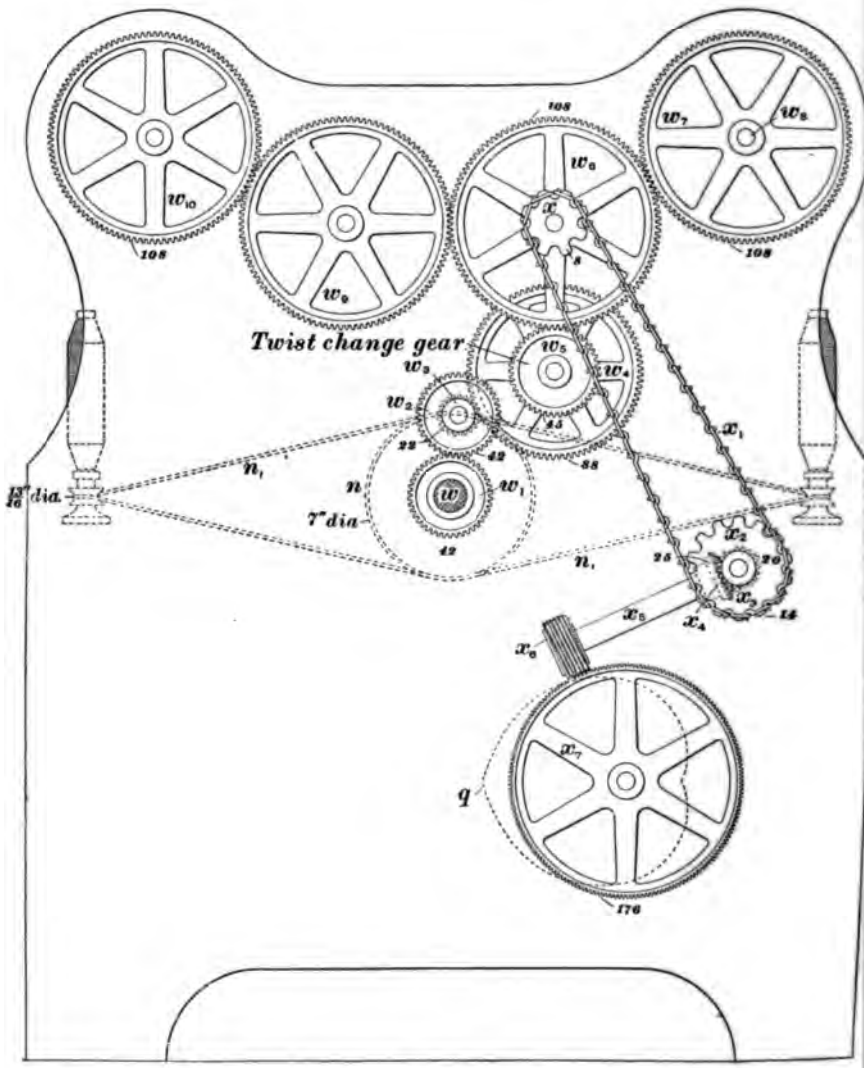

Twist change gear
w_{10}
w_9
w_8
w_7
w_6
w_5
w_4
w_3
w_2
w_1
w
x
x_1
x_2
x_3
x_4
x_5
x_6
x_7
n
n_1
q
108
176
22
42
44
88
25
20
14
8
$\frac{13}{16}$" dia.
7" dia.

FIG. 1

gear w_{10} through the carrier w_9. The gear w_{10}, being on the front roll shaft situated on this side of the machine, imparts motion to the second set of rolls. By introducing the carrier w_9 the direction of motion of the gear w_{10} is opposite to that of the gear w_7; this is necessary, since the rolls on the two sides of the frame must revolve in opposite directions in order to deliver the stock to their respective sides. Compounded with

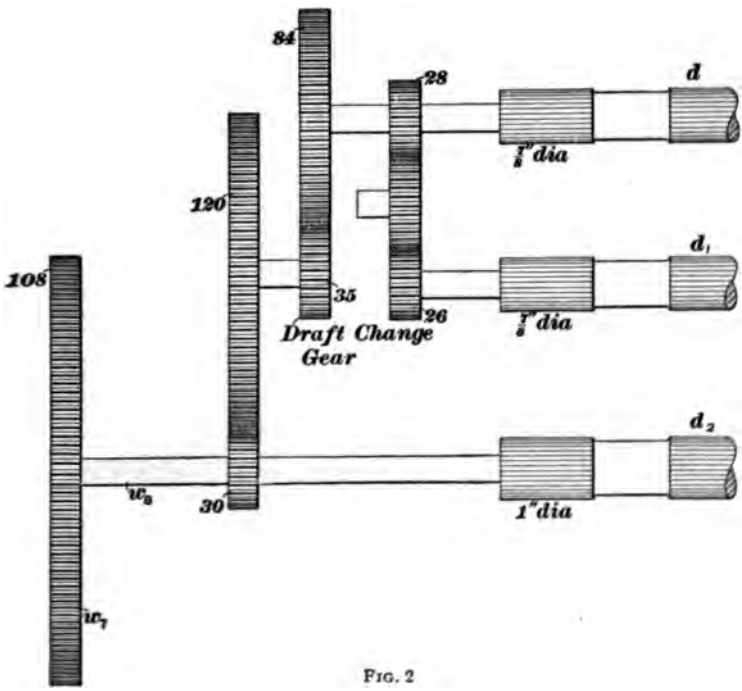


FIG. 2

the gear w_8 is a sprocket gear x that drives, by means of the chain x_1, the sprocket gear x_2. Compounded with x_2 is a bevel gear x_3 meshing with the bevel gear x_4 on a short shaft x_5. This shaft carries at its opposite end the single worm x_6 gearing into the worm-gear x_7, which is on the shaft with the cam q of the builder motion.

Referring to Fig. 2, the gear w_7, also shown in Fig. 1, that is on the front roll shaft w_6, imparts motion to the front

roll d_3. A small gear of 30 teeth on the shaft w_6 drives, through suitable gearing, the back roll d, while a gear of 28 teeth on the back roll shaft drives, through a carrier, the gear on the shaft of the middle roll d_1.

SPEED CALCULATIONS

2. As rules and explanations for performing speed and draft calculations have been given in previous Sections, no rules will be given in cases where such subjects are here dealt with, but examples are given of all the calculations met with in connection with spinning frames. It should be noted that while the calculations in the succeeding examples have been carried to three decimal places, this does not signify that these decimal figures are absolutely necessary. On the contrary, they might have been omitted without invalidating the accuracy of the answers, as the available data as to diameters of cylinder and whorls and the amount of slippage are not reliable. They have been retained in order to preserve a certain uniformity in the answers.

EXAMPLE 1.—Find the speed of the cylinder n, Fig. 1, when the driving shaft makes 400 revolutions per minute and carries a 30-inch pulley that drives a $10\frac{3}{4}$-inch pulley on the cylinder shaft w.

SOLUTION.—

$$\frac{400 \times 30}{10\frac{3}{4}} = 1{,}116.279 \text{ rev. per min.} \quad \text{Ans.}$$

EXAMPLE 2.—If the cylinder n, Fig. 1, makes 1,116.279 revolutions per minute, find the speed of the front roll shaft w_6.

SOLUTION.—

$$\frac{1{,}116.279 \times 42 \times 22 \times 45}{42 \times 88 \times 108} = 116.279 \text{ rev. per min.} \quad \text{Ans.}$$

EXAMPLE 3.—If the cylinder n, Fig. 1, is 7 inches in diameter and makes 1,116.279 revolutions per minute, find the speed of the spindles if the whorl around which the band passes is $\frac{1}{16}$ inch in actual diameter.

NOTE.—In connection with finding the speed of spindles a question arises as to where the diameter of the whorl should be taken. It is customarily taken at the bottom of the groove, although theoretically the diameter should be considered a little larger than this, in order to allow for the thickness of the spindle band; consequently, the calculation should be made with the diameter taken at the center of the band, about $\frac{1}{16}$ inch being added to the diameter of the whorl in order to make allowance for this, this dimension being termed the *working diameter*.

SOLUTION.— $\frac{11}{16}$ in. + $\frac{1}{16}$ in. = $\frac{12}{16}$ in., working diameter of whorl.

$\frac{1{,}116.279 \times 7}{\frac{12}{16}}$ = 9,617.172 rev. per min.

NOTE.—The question of slippage also arises in connection with the speed of the spindles. This is a variable quantity, depending on the tension of the bands, the oiling of the spindles, the number of the yarn being spun, the weight of the travelers, and other factors. The loss from the calculated speed of the spindles, due to slippage, will vary from 5 to 10 per cent., but as 5 per cent. is the customary allowance it will be adopted in these calculations. Making this allowance, example 3 would be completed as follows:

100 per cent. − 5 per cent. = 95 per cent., or .95.

9,617.172 × .95 = 9,136.313 rev. per min. Ans.

3. To find the speed of the traveler when the speed of the spindle, the speed of the front roll, and the diameter of the bobbins are known:

Rule.—*Find the number of revolutions per minute of the bobbin necessary to take up the amount of yarn delivered per minute by the front roll. Subtract this number of revolutions per minute of the bobbin from the revolutions per minute of the spindle.*

EXAMPLE.—If the spindles make 9,136.313 revolutions per minute and the front roll delivers 365.302 inches per minute, what is the speed of the travelers when the bobbins are $\frac{7}{8}$ inch in diameter?

SOLUTION.— $\frac{365.302}{\frac{7}{8} \times 3.1416}$ = 132.890, the rev. per min. of bobbins necessary to take up amount delivered by front roll.

9,136.313 − 132.890 = 9,003.423 rev. per min. of traveler. Ans.

TWIST CALCULATIONS

4. To make an absolutely accurate calculation of the twist, i. e., the number of turns per inch being placed in the yarn, it would be necessary to find the actual number of revolutions of the traveler in a certain period, say 1 minute, and the actual length, in inches, of yarn delivered during that period. The turns per inch would then be found by dividing the speed of the traveler by the length of yarn.

There are certain difficulties that present themselves in finding this data. For instance, if the circumference of the front roll is multiplied by its revolutions per minute, it gives the distance traveled in 1 minute by a point on its circumference, which corresponds to the length of untwisted yarn delivered from the front roll; but this does not accurately represent the amount of yarn spun, for as the twist is inserted

in the stock, it contracts slightly, and the actual length of yarn is usually assumed to be about 5 per cent. less than the delivery of the front roll, although this varies according to the number of the yarn, the twist per inch being inserted, and other conditions that make an arbitrary allowance impossible. It is sufficient to say, however, that if the calculations were made on the basis of the length of roving delivered by the front roll, assuming this to be the length of the yarn, the result would not accurately represent the turns per inch, which would be greater in practice than the calculations would show.

Difficulties also arise in the calculation of the actual speed of the traveler. In calculating this from the speed of the cylinder, two difficulties that are met with have already been mentioned; namely, the question as to what diameter should be taken for the whorl, also the amount of slippage between the cylinder and the spindle band, and between the spindle band and the whorl. Even if the speed of the spindle were accurately found, another difficulty would be met with in making the proper deduction from this speed to obtain the speed of the traveler. This allowance varies in case of a filling wind according to whether it is taken at the small or the large diameter at each end of the traverse or at an intermediate point. In case of a warp wind, as the bobbin becomes larger the speed of the traveler is gradually being increased, since with each layer wound on the bobbin a smaller difference in speed between the spindle and the traveler is required for winding the yarn.

Even if reasonably accurate data could be ascertained, so as to make suitable allowances for the various losses mentioned, local or temporary conditions, such as changes in the atmospheric conditions, in the humidity of the room, variations in the stock, or unevenness of the roving, would render the conclusions inaccurate; it is therefore customary for practical millmen to consider that the increase in the number of turns per inch above the calculated number produced by contraction of the stock as it is being made into yarn about compensates for the reduced speed of the traveler as compared with that of the spindle and the other losses named.

For all practical purposes, it is considered sufficiently accurate to divide the length of stock delivered by the front rolls into the calculated speed of the spindle, making no allowance for slippage, and accept the result as representing the actual turns per inch that may be expected to be obtained.

The following calculations are made on this basis. To find the turns of twist per inch being placed in the yarn:

Rule I.—*When figuring from the gears, consider the gear on the end of the front roll as a driver. Multiply all the driving gears and the diameter of the cylinder together and divide by the product of all the driven gears, the working diameter of the whorl, and the circumference of the front roll.*

EXAMPLE 1.—What is the twist per inch that is being placed in yarn spun on a frame geared as shown in Fig. 1 if the diameter of the front roll is 1 inch, the cylinder 7 inches, and the working diameter of the whorl $\frac{11}{16}$ inch?

SOLUTION.—

$$\frac{108 \times 88 \times 42 \times 7}{45 \times 22 \times 42 \times \frac{11}{16} \times 3.1416 \times 1} = 26.326, \text{ turns per in. Ans.}$$

Rule II.—*In case the speed of the spindles and the number of inches of yarn delivered by the front roll are known, divide the speed of the spindles, without any allowance for slippage, by the inches delivered per minute by the front roll.*

EXAMPLE 2.—What is the twist per inch that is being inserted in yarn if the spindles make 9,617.172 revolutions per minute and the front roll delivers 365.302 inches per minute?

SOLUTION.— $9{,}617.172 \div 365.302 = 26.326$, turns per in. Ans.

5. To find the constant for twist from the gears:

Rule.—*Consider the gear on the end of the front roll as a driver and the twist gear as a 1-tooth gear. Multiply together all the driving gears and the diameter of the cylinder and divide by the product of all the driven gears, the working diameter of the whorl, and the circumference of the front roll.*

EXAMPLE.—What is the constant for twist with the frame geared as shown in Fig. 1 if the diameter of the front roll is 1 inch, the cylinder 7 inches, and the working diameter of the whorl $\frac{11}{16}$ inch?

SOLUTION.—

$$\frac{108 \times 88 \times 42 \times 7}{1 \times 22 \times 42 \times \frac{11}{16} \times 3.1416 \times 1} = 1{,}184.697, \text{ constant. Ans.}$$

6. To find the twist per inch when the constant for twist and the twist gear are known:

Rule.—*Divide the constant by the number of teeth in the twist gear.*

EXAMPLE.—What is the twist per inch that is being inserted in yarn if the constant for twist is 1,184.697 and the twist gear contains 45 teeth?

SOLUTION.— 1,184.697 ÷ 45 = 26.326, turns per in. Ans.

7. To find the necessary twist gear to give a required number of turns per inch when the constant is known:

Rule.—*Divide the constant by the twist required.*

EXAMPLE.—If the constant for a train of gears is 1,184.697, what size twist gear will be required to give 20 turns per inch in the yarn?

SOLUTION.—

1,184.697 ÷ 20 = 59.2, or a 59-tooth gear (practically). Ans.

The calculations given in connection with twist make no allowance for any slippage that may occur, or for any loss caused by the traveler speed being slightly less than the spindle speed. These points are sometimes taken into consideration, although the contraction of the yarn, due to the twist inserted, generally compensates for any loss due to these causes.

8. In determining the amount of twist to be placed in either warp or filling yarn spun on a ring frame, a constant is used that multiplied by the square root of the counts gives the required number of turns per inch. For ordinary warp yarn spun on ring frames the constant is usually 4.75, but for filling it is 3.25. These figures, however, are varied according to the twist required, the quality of the yarn to be made, or the kind of stock being used. Long stock does not require so much twist in proportion as short stock. Filling yarn from carded stock requires, as a rule, from $1\frac{1}{4}$ to $2\frac{1}{2}$ turns per inch more twist than the square root of the counts multiplied by 3.25. On combed stock the standard number of turns is sufficient, since combed stock does not require so much twist for the same numbers as carded stock.

Fine filling yarns or yarns for twisting are spun with less twist than 3.25 times the square root of the counts.

EXAMPLE 1.—What is the standard twist in 28s warp yarn?

SOLUTION.— $\sqrt{28} = 5.291$. $5.291 \times 4.75 = 25.132$, turns per in. Ans.

EXAMPLE 2.—What is the standard twist in 36s filling yarn?

SOLUTION.— $\sqrt{36} = 6$. $6 \times 3.25 = 19.5$, turns per in. Ans.

DRAFT CALCULATIONS

9. Draft calculations are of importance in connection with ring spinning frames, as the draft, together with the hank of the roving, governs the size of the yarn produced.

EXAMPLE 1.—Find the draft for rolls geared as shown in Fig. 2.

SOLUTION.— $\frac{1 \times 120 \times 84}{30 \times 35 \times \frac{7}{8}} = 10.971$, draft. Ans.

EXAMPLE 2.—Find the draft constant for the rolls when geared as shown in Fig. 2.

SOLUTION.— $\frac{1 \times 120 \times 84}{30 \times 1 \times \frac{7}{8}} = 384$, constant for draft. Ans.

PRODUCTION

10. To find the hanks per spindle per day:

Rule.—*Divide the product of the circumference of the front roll, the number of revolutions per minute of the front roll, the minutes per hour, and the hours per day by the product of the number of inches in 1 yard and the number of yards in one hank.*

EXAMPLE.—How many hanks per spindle, per day of 10 hours, will be produced by a frame with a front roll 1 inch in diameter that makes 116.279 revolutions per minute?

SOLUTION.—

$$\frac{1 \times 3.1416 \times 116.279 \times 60 \times 10}{36 \times 840} = 7.248, \text{ hanks per spindle per day.}$$

Ans.

When figuring the production of ring frames from the speed of the front roll it is necessary to make certain allowances, since the frame is not running continually, owing to the stoppages necessitated by cleaning, oiling, and doffing. These allowances will vary with the yarn spun, since coarse yarn

requires more frequent doffing than fine yarn, owing to the bobbins being filled more rapidly. The following table gives the allowances usually made for the different counts of yarn:

TABLE I

Warp Yarn		Filling Yarn	
Numbers	Allowance Per Cent.	Numbers	Allowance Per Cent.
5s to 10s	11	5s to 10s	14
10s to 20s	10	10s to 15s	12
20s to 30s	9	15s to 20s	11
30s to 40s	8	20s to 30s	10
40s to 55s	7	30s to 35s	8
55s to 85s	4	35s to 45s	7
85s to 100s	2	45s to 60s	6

11. To find the total production, in pounds, of several frames when the number of hanks produced by each spindle is known:

Rule.—*Find the production, in pounds, of each frame by multiplying the number of spindles in the frame by the hanks produced by each spindle and dividing the result by the counts being spun. Add the results obtained for each frame.*

EXAMPLE.—If four frames of 160 spindles produce, respectively, 37 hanks per spindle of 36s, 33 hanks per spindle of 50s, 28 hanks per spindle of 70s, and 27 hanks per spindle of 80s, in 1 week, what is the total production for the week?

SOLUTION.— $\frac{160 \times 37}{36} = 164.444$ lb. of 36s

$\frac{160 \times 33}{50} = 105.6$ lb. of 50s

$\frac{160 \times 28}{70} = 64$ lb. of 70s

$\frac{160 \times 27}{80} = 54$ lb. of 80s

$164.444 + 105.6 + 64 + 54 = 388.044$ lb., total production for 1 wk. Ans.

12. To find the average number of yarn being produced:

Rule.—*Multiply the number of pounds produced by each frame by the counts of yarn being spun. Add the results thus obtained and divide by the total number of pounds.*

EXAMPLE.—What is the average number of yarn being spun if four frames produce, respectively, 164.444 pounds of 36s, 105.6 pounds of 50s, 64 pounds of 70s, and 54 pounds of 80s?

SOLUTION.—

164.444 × 36 =	5919.984
105.600 × 50 =	5280.000
64.000 × 70 =	4480.000
54.000 × 80 =	4320.000
388.044	19999.984

19,999.984 ÷ 388.044 = 51.540s, average number of yarn. Ans.

NEW FRAMES

13. Great care should be taken in selecting frames for different purposes or in making out specifications for the building of frames. All parts should be properly proportioned according to whether they are to spin warp or filling; fine, medium, or coarse yarns; and, to some extent, according to the purposes for which the yarn is required.

14. **Gauge.**—One of the first things to determine is the gauge of the frame, that is, the distance between the centers of two consecutive spindles; this is usually fixed at $2\frac{1}{4}$ inches, except where the size of the ring to be used is so large that a larger gauge must be selected. The diameter of the ring is generally about 1 inch less than the gauge of the frame, although it is sometimes within $\frac{1}{4}$ inch of the gauge and at other times considerably less than the gauge of the frame. Thus, a $2\frac{1}{4}$-inch gauge frame under certain conditions could use either a 2-, $1\frac{7}{8}$-, $1\frac{3}{4}$-, $1\frac{5}{8}$-, $1\frac{1}{2}$-inch, or a smaller ring, usually a size not larger than a $1\frac{3}{4}$-inch nor smaller than a $1\frac{1}{4}$-inch. Filling frames require a smaller ring than warp frames for the same numbers, because the filling being weaker, will not stand the excessive traveler pull that exists when a small bobbin is used in a large ring; there is also a limit to the size of the filling bobbin that can be placed in

TABLE II

Warp			Number of Yarn	Filling		
Gauge of Spindles Inches	Diameter of Ring Inches	Length of Traverse Inches		Gauge of Spindles Inches	Diameter of Ring Inches	Length of Traverse Inches
$3\frac{1}{4}$	$2\frac{1}{4}$	7	4	$2\frac{3}{4}$	$1\frac{5}{8}$	$6\frac{1}{2}$
			9			
			10			
3	$2\frac{1}{8}$		11			
			15			
			16		$1\frac{1}{2}$	
			17			
	2		20			
			21			
	$1\frac{7}{8}$		25			
			26			6
		6	27		$1\frac{3}{8}$	
	$1\frac{3}{4}$		28			
			30			
			31			
			35			
$2\frac{3}{4}$			36			
	$1\frac{5}{8}$		37			
			39			
			40			
			41			$5\frac{1}{2}$
	$1\frac{1}{2}$		44			
			45			
			50			
		$5\frac{1}{2}$	51			
	$1\frac{3}{8}$		60		$1\frac{1}{4}$	5
			70			
		5	80			

the shuttle of the loom. The use of separators enables larger rings to be used for the same gauge of frame than would otherwise be possible.

15. The length of the traverse should be less for fine yarns than for coarse yarns; $5\frac{1}{2}$ inches is about the average, 7 inches being about the maximum traverse and $4\frac{1}{2}$ inches the minimum. Long traverses are used for coarse yarns, and short traverses for fine yarns. The speed of the spindle has to be higher in making fine yarns than in the case of coarse yarns and higher for warp yarns than for filling yarns, because the additional amount of twist that has to be put in the fine yarn or warp yarn will seriously reduce the speed of the front roll, and consequently the production of the frame, if the spindle speed is not high.

Table II will show approximately the customary gauge of the spindles, the diameter of the rings, and the length of traverse for the principal numbers of warp and filling yarns between 4s and 80s.

This table is based on the modern tendency to use large rings and a long traverse; some mills, however, are using smaller rings. Large bobbins should be used with large rings, especially for filling. For experimental purposes, 80s yarn has been spun from combed sea-island stock with a 7-inch traverse and 2-inch ring; the table, however, does not include such purely experimental results as this, but is figured on a commercial basis.

BOBBINS

16. The selection of the bobbins is another important point. The diameter of the barrel should be great enough to prevent undue strain (traveler pull) on the yarn when winding on the bare bobbin, yet not so great as to reduce to an unprofitable quantity the yarn that can be wound on them, because the less yarn that can be placed on the bobbin, the oftener must the frame be doffed. In the case of filling yarn, the ordinary loom has to stop oftener to have the

bobbin replaced when there is a short length of yarn on the bobbin.

The bobbin should fit the top of the spindle closely, but not tightly, and should fit snugly the sleeve bearing for a distance of about $\frac{5}{8}$ inch. Where a cup is used it should project into the cup about $\frac{1}{8}$ inch. The following table gives suitable sizes of bobbins for various numbers of yarn, both warp and filling, assuming that the proper size of ring is used as given in Table II. A larger ring than that shown in the table for any specified number requires a larger bobbin.

TABLE III

Numbers of Yarn	Diameter of Barrel	
	Warp Inch	Filling Inch
4s to 16s	$\frac{3}{4}$	$\frac{1}{2}$
16s to 30s	$\frac{3}{4}$	$\frac{1}{2}$
30s to 40s	$\frac{3}{4}$	$\frac{5}{8}$
40s to 100s	$\frac{7}{8}$	$\frac{5}{8}$

Warp bobbins are usually smooth on their outside surfaces, but filling bobbins have either ridges or grooves about $\frac{1}{4}$ inch apart to prevent the yarn from slipping off the bobbin when being picked across the loom. The ridges are better than the grooves, as the bobbin is stronger. It is a good thing to have slight grooves or ridges, even in warp bobbins, to prevent the yarn from being pulled off by a careless spooler tender or negligent spinner and also to give the yarn a better grip on the bobbin in starting a new set.

TRAVELERS

17. A point that should be noted in connection with ballooning is that the centrifugal force tends to carry the traveler toward the outside of the ring when the spindle is revolving at a high rate of speed. This tendency, to some

extent, is lessened by the action of the separator blades, which are continually reducing the centrifugal force of the yarn, but counteracts the pull of the yarn inside the ring somewhat and thus reduces the friction of the traveler, since the traveler being subjected to this force presses more lightly on the ring. The traveler, also, develops centrifugal force, which tends to drive it against the inside of the flange of the ring, while the yarn tends to pull it against the outside of the flange; but as the weight of the traveler is very small this force does not amount to much. In practice, however, it is found that rings become worn more on the inside than on the outside and that spinning fine yarns wears the rings out more quickly than spinning coarse yarns.

Other influences on the action of the traveler are the weight of the yarn itself, the speed of the spindle, and the varying diameter of the bobbin as it gradually increases in size. Coarser yarn is heavier to pull around and develops more centrifugal force; it consequently requires heavier travelers, which it will stand in consequence of its greater strength. High-speeded spindles put more strain on the yarn and wear on the traveler in dragging the latter around the ring more rapidly. The bobbin when filled with yarn eases the work of the traveler. This is more noticeable in the filling-wind frame than in the warp-wind frame, since the diameter of the part of the bobbin where the yarn is being wound varies constantly, while in the warp-wind bobbin the variation is a gradual one extending over the building of the whole bobbin.

In connection with the ring spinning frame, many controversies have arisen regarding the theoretical irregularity of twist caused by the varying speed of the traveler, according as the bobbin is small or large on a warp-wind or is winding on the small or large diameter on a filling-wind. For all practical purposes this can be ignored, as it only amounts to about 2 per cent. more twist on a warp-wind bobbin nearly full than when the same bobbin is just started. In a filling-wind it is less than this, as the twist tends to equalize itself on account of the 10 or more inches of yarn between the rolls and traveler into which the twist runs.

TABLE IV

Number of Yarn	Size of Traveler for 1½-Inch Ring	Size of Traveler for 1⅝-Inch Ring	Size of Traveler for 1¾-Inch Ring
6	12	11	10
8	10	9	8
10	8	7	6
12	7	6	5
14	6	5	4
16	5	4	3
18	4	3	2
20	3	2	1
22	2	1	1–0
24	1	1–0	2–0
26	1–0	2–0	3–0
28	2–0	3–0	4–0
30	3–0	4–0	5–0
32	4–0	5–0	6–0
34	5–0	6–0	7–0
36	6–0	7–0	8–0
38	7–0	8–0	9–0
40	8–0	9–0	10–0
42	9–0	10–0	
44	10–0	11–0	
46	11–0	12–0	
48	12–0	13–0	
50	13–0	14–0	
52	14–0	15–0	
54	15–0	16–0	
56	16–0	17–0	
58	17–0	18–0	
60	18–0	19–0	

18. It is impossible to give a definite rule by which to find the weight of traveler to use for a certain counts of yarn, as this varies not only in different mills but in the same mill at different times and on different machines. The following are general principles, however: (1) A larger ring, other conditions being alike, requires a lighter traveler. (2) A change to a coarser yarn, other conditions being alike, requires a heavier traveler. (3) Putting more twist into the yarn may require a heavier traveler. (4) A better grade of stock, for example Egyptian cotton instead of American, will stand a heavier traveler. (5) Old rings require heavier travelers than new ones; frames are usually started with light travelers and run with them until the rings become smooth from wear, after which a heavier traveler is required, in order to obtain the required tension on the yarn. (6) During moist, sticky weather travelers run hard and fly off; under these circumstances a lighter traveler should be used. (7) Short stock, weak staple, or heavily drafted yarns require a lighter traveler than the same numbers spun under better conditions. In case of doubt, the preference should be given to the heavier traveler if the yarn will stand it, as a heavier traveler will make a firmer bobbin, which is generally desirable.

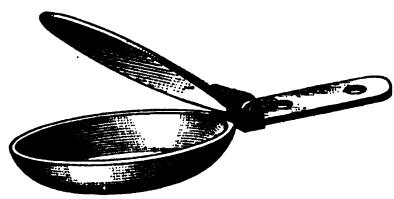


FIG. 3

In order to give a general idea as to the size of traveler to use, Table IV is given; but it must be remembered that this is only given as a guide and that the best traveler to use can only be determined by experimenting with a few sizes. Care should be taken when changing from one make of traveler to another to make allowance for the difference in the weight of 100 travelers of the new make as compared with the old, which may vary, even if the number of the traveler is the same.

19. Travelers should be replaced when they become worn. Care should be taken that the proper size of traveler

is put on and that different sizes of travelers do not become mixed. It is economical to have attached to the frame a *traveler cup*, which is a little box with a lid, shown open in Fig. 3, in which a supply of travelers may be kept.

OPERATIONS ATTENDANT ON SPINNING

20. The work of running spinning frames is done by tenders, generally girls, who are paid so much a side; that is, one side of one frame. The number of sides that each tends varies according to the length of the frame, the numbers of the yarn, the grade of stock being used, and the ability of the tender. The average for coarse yarns is 1,000 spindles to a tender; for medium yarns, 1,200 spindles; and for fine yarns, 1,400 spindles. The work of the tenders consists chiefly in piecing up broken ends, replacing travelers, and cleaning the upper parts of the frame; they should, however, be trained to take an interest in their work besides merely piecing up ends. For instance, they should endeavor to detect spoiled or worn travelers; to determine when top rolls are too much worn for further use; to see that the saddles, weight levers, and weights are always in proper position; and to keep a watchful eye on the work generally and report anything wrong.

CREELING

21. **Creeling** is generally performed by the tender, or spinner, although in some mills extra creelers replace the bobbins as they run off. It is advisable to see that short piecings are made and that the piecings are not too hard to draw out in the draft rolls. It is customary to have a different amount of roving on the different bobbins in the same creel of a spinning frame so that they will not all run out together.

DOFFING

22. **Doffing** is the replacing of full bobbins of yarn with empty ones. Although the operation differs, in detail, on different makes of frames, the following description shows how it is usually performed. Just before the frame is stopped,

the doffers place in the alley a truck bearing a box divided into two parts, one of which is to receive the full bobbins as they are taken from the frame, while the other contains empty bobbins. When the frame is stopped, the ring rail is dropped to its lowest position by means of a foot-lever attached to one of the rods supporting the weights beneath the frame; a notch in it catches under a suitable projection and holds the rail in this position while the frame is being doffed. The frame is then run a moment to give a little slack to the ends; the thread boards and separators are then pushed back out of the way. The doffer takes off the full bobbins with one hand and with the other hand places empty bobbins in the place of the full bobbins that have been removed from the spindles. In taking off the full bobbin, the slack end unwinds a little before breaking and winds around the spindle; as the empty bobbin is put on over the spindle the bottom of the bobbin grips the thread and no further piecing is needed, except where an end breaks too short to allow the bobbin to grip it.

The full bobbins are deposited in the empty part of the box on the truck, and after all the full bobbins have been removed and empty ones put in their places the builder motion is set in its correct position for winding on an empty bobbin, the thread boards let down to their working position, the separators dropped, and the frame started. The ring rail is then traversed up and down several times to bind the first spirals of thread wound on. All ends that are broken are pieced up in the following manner: The tender places a full bobbin between her teeth, while with one hand she winds the thread around the empty bobbin and with the other hand runs the thread through the traveler and pieces the end to the end that is being delivered by the rolls.

CLEANING

23. Creels should be cleaned twice a week; that is, the dirt that has accumulated either on the skewer tops or bottoms should be removed and the creels thoroughly wiped down;

it is necessary to dust them oftener than this. The rolls, especially the bottom steel rolls, are apt to accumulate fiber and dirt and should be rubbed down with dry, soft waste twice a week. The lifter rods, builder, and all slowly moving parts should be cleaned at the same time. Other parts require a thorough cleaning more frequently than this. For instance, the ring rail should be brushed every time the frame is doffed; the thread boards and roll beams should be wiped off three times a day; top clearers should be picked twice a day and the bottom clearers as required; other parts of the frame should be thoroughly cleaned twice a week.

Generally speaking, the work of cleaning is attended to by the spinners, but in some mills small boys are employed to attend to such general cleaning as weights, head ends, sampsons, foot-ends, etc. The times of cleaning named above are not sufficiently frequent where coarse carded yarns are being spun.

The spindles should be taken out and cleaned at least twice a year, when the dirty oil may be pumped out and the bolster base and other parts thoroughly cleaned.

OILING

24. The oiling of ring spinning frames is very important, as is the oiling of all textile machinery. In the larger mills, oilers are usually employed solely for this work. The spindles having oil reservoirs should be oiled every two or three weeks; those without reservoirs should be oiled more frequently. Some spinners recommend adding a little oil each week to spindles with reservoirs. The quickly running parts, such as loose pulleys and cylinders, should be oiled daily, as should the top front rolls. The back and middle rolls do not require oiling so frequently, especially where the lubricating saddles are used, but should be oiled at least once a week. All other moving parts, such as the builder and the bearings of the lifter brackets, should be oiled every week.

Care should be taken in oiling all machines, and the help employed for this should be well selected. A good oiler

will repay his wages in the saving of oil, and in attending to his duty will increase the production and the life of the machinery. It is not advisable to use the cheap oils, which are liable to gum and stick and have a high viscosity. An oil of a medium to light specific gravity is better—not so light as to leak through the pores of the cast-iron spindle bases, and not so heavy as to cause additional friction. A specific gravity corresponding to about 33 to 38° on a Beaumé hydrometer is most satisfactory.

BANDING

25. Banding a spinning frame is one of the most important features in connection with it. Slack bands tend to make soft yarn and soft bobbins; tight bands absorb power unnecessarily. Since any part of a band must bend around a whorl about $\frac{3}{4}$ inch in diameter 8,000 or 10,000 times a minute, it is necessary that all bands be made of suitable material, so that they will not become slack after running a short time, and that the knots should be so made that they will not present much obstruction in passing round the small whorl of the spindle and thus cause a jerking or jumping motion.

It is customary to test the tension at which bands are running. While it is possible to run satisfactorily a spindle with an initial band tension of 1 pound, it is not possible to have all the bands at this tension and so made and tied as not to lose speedily their grip on the whorl of the spindle. It is therefore more satisfactory to start bands with an initial tension of about 3 pounds, and allow them to run down to 2 pounds, as this allows for the increase of tension that occurs in wet weather or after the frames have been standing, especially in the case of a low temperature. Besides, this tension is large enough to eliminate the possibility of slow running of the spindles and the consequent soft bobbins of slackly twisted yarn.

26. Bands may be made of yarn or roving or of a combination of both. They are customarily made of various

machines that stop automatically when a certain length of band has been made and a certain amount of twist put in, so that all are uniform. Bands made of roving are usually preferred to those made of yarn, but it should not be thought that any waste material is good enough for making bands, as poor bands are far from being economical. The main requisite of a good band is that it will not stretch. The yarn or roving should be of good quality and a large number of bands should be made at one time from the same grade of stock, hank of roving, or number of yarn, so as to maintain a regularity in the bands that are used over a considerable period.

One method of making bands is to use four strands of 2-hank roving with about two and one-half times the usual amount of twist, or about three and three-quarter turns per inch. Four bobbins of this roving are placed in the banding machine and equal lengths from the four bobbins twisted into one strand, after which the process is completed by twisting together two of these strands with about four turns per inch of twist. The completed band, therefore, consists of two strands twisted together, each strand being made by twisting together 4 ends of roving. Since the roving has also been twisted, this gives three processes of twisting to complete the band, which results in a very strong, hard product well suited to fulfil the requirements of the spinning frame. The band, when completed, generally has a loop at one end which facilitates tying at the spinning frame. Bands made in this manner are known as *loop bands*.

Another method of making bands is to use eight strands of 8-hank roving with a core band of eight threads of number 30s yarn. The roving is twisted in the twisting machine before being made up on the banding machine, where the core band and the roving are twisted together.

Another method is to use yarn only. In this case about 36 ends of yarn are twisted together to form a strand and two of these strands then twisted to form a loop band.

Bands are usually made between 100 and 130 to the pound and should not weigh less than 115 nor more than 125 to the

pound for a frame 39 inches wide. Very often a mark is made on the band to show the point to which it must be drawn in tying it on, with a view to securing an even tension. Banding can be made in one continuous cord and is generally supplied in this form wound in the shape of a ball. In Europe, it is almost always customary to use bands in this form, the loop band being a feature of American mills only.

27. The spindle is generally banded by a special operative, called a band boy, although in small mills the oiler may attend to the duty of both oiling and banding the frames; in other cases, the second or third hands band the frames. In putting on a band, a jack-knife is closed on one end of it and inserted in a curve in a specially bent wire. The end of the band and knife are passed over the cylinder and the wire withdrawn and passed under the cylinder, when the operative catches the hanging end of the band and draws it to him.

When a loop band is used, the loose end should be divided into two strands and both strands passed through the loop, one in one direction and the other in the opposite direction; the two loose strands should then be tied together, pulling them sufficiently tight to bring the mark on the band to the loop on the other end of the band. A square knot is tied. The frame is not stopped during this operation.

A method of replacing the old band with a new one when the old one is still in position is temporarily to attach one end of the new band to the old one. As the old band continues its motion the end of the new band is carried around the cylinder and back to the front of the frame. The old band can now be cut with a knife and removed and the new one tied in place and allowed to drive the spindle. The spare amount of banding, or ends, that remain after the proper length has been used and the knot tied, should be cut off to within about $\frac{1}{4}$ inch of the knot. This is the usual method of replacing the bands when they become too slack or worn to drive the spindles satisfactorily.

SCOURING

28. Spinning frames on which yarns above 50s are being spun should be scoured thoroughly once a year; when the yarns are between 30s and 50s, about twice a year; while those spinning lower than 30s, about three times a year.

It is customary in some mills to wash ring rails and rings once a year in tanks long enough to contain the longest rail. In one tank is a strong solution of ammonia and water, while the other contains clean water; the contents of both tanks are kept at the boiling point. Near these tanks is a tray of sawdust. The rails and rings together are soaked in the ammonia water for about 3 minutes, afterwards being rinsed in the clean water and dried in the sawdust. As they are hot they do not rust, but come out bright and clean.

GENERAL CARE OF SPINNING FRAMES

29. The making of good yarn is largely a matter of attention to detail. Of course the stock must be good enough for the purpose, or good yarn cannot be made. The hank of the roving should not be so low as to necessitate too large a draft. Where double roving is used for warp, the draft should not exceed twelve for numbers 25s to 40s, while for coarser numbers than this the draft should be reduced, on account of the greater weight of the roving that is being drawn; for finer numbers the draft should also be reduced, to about eleven on number 50s, about ten on number 60s, and still less for finer numbers, in order to make the work run well. Where double roving is used for filling the draft should not be higher than thirteen on numbers 25s to 35s, and this should be reduced to as low as nine, ten, or eleven on coarser numbers and to about twelve for number 40s, eleven for number 50s, ten for number 60s, and even less for finer yarns. These figures, of course, are not arbitrary, as longer drafts can be used if stock is of extra quality or if it is combed as well as carded, while shorter drafts are sometimes necessary in other cases.

Double roving on spinning frames is much more common in America than in any other country. It is customary abroad on both mules and ring frames to use single roving for all numbers up to 50s and even higher, double roving being used only for the finer yarns. It is an unsettled point whether single roving could not be introduced for the lower numbers in the United States with advantage in many cases and reduce the expense of making the yarn. To spin a 28s, for instance, with a draft of twelve necessitates a roving of 4.66 hank. With single roving, say 4-hank, the draft could be reduced to seven, which would be much easier on the stock as it is being drawn in the rolls; the 4-hank roving is also cheaper to make than a 4.66- or a 5-hank roving. Even a 3½-hank roving could be used, which would give a draft of only eight, and still a good yarn be made, while the 3½-hank roving would be much cheaper than 4.66-hank. In other words, the excessive draft usually required when using double roving in the average American mill nullifies to some extent the advantage of doubling. A stronger yarn can be made by spinning from double roving than from single roving, out of the same cotton, but at a greater expense per pound.

30. Care of Rolls.—Other things that require attention in order to keep up the quality of the yarn are the rolls, especially the top rolls, which should be recovered when worn or when they become fluted or channeled. A good way to test the evenness of a roll is as follows: Place the roll on a perfectly plane surface, roll it back and forth a full revolution and observe the light that passes between it and the surface on which it rests. If the roll is as it should be, very little if any light can be seen, while if it is uneven, some parts of the roll will touch, while others will show light between. Rolls so uneven as this are not fit to run on fine work either as middle or front rolls. On very coarse work, however, these defects will not amount to much; still a better roll would be preferable.

Top rolls should be put in the frame so that the lap on the leather will not turn up in working; that is, the lap should

follow on the outside. Any cotton that collects on the bosses of the rolls should be removed immediately in order to prevent the rolls becoming injured.

In addition to making drafts as light as possible, rolls should be set the right distance apart and the roving should not contain too many turns per inch, merely having sufficient turns to enable it to draw the bobbins around in the creels. The roving trumpets should be kept clean; otherwise, cotton and dirt gather there, causing additional strain and draft on the roving before it enters the rolls. The trumpets should be set so that at the center of their traverse they will be at the center of the boss of the top roll, and should not be allowed to become loose or tip over. Rolls, especially top rolls, should not be allowed to become dry at the bearings through neglect in oiling; otherwise they drag and their speed is reduced, producing, in the case of front rolls, yarn coarser than it ought to be, sometimes to the extent of five or six numbers. This also causes the rolls to make rough, lumpy, fuzzy, and uneven yarn and increases the power necessary to drive the frame.

Waste is apt to gather at the ends of the top roll and form a hard cake, which, unless picked off, retards the motion of the roll and produces the same effect as a dry roll. Sometimes hard cakes of dirt form on the arbors of the shell rolls with the same result.

When the saddles are set on the top rolls the wrong way, it results in improperly distributing the weight on the rolls. When they are worn they have too much bearing surface on the rolls and retard their movement to some extent, thus causing an irregularly drawn yarn to be made. The weights should always be set in the right place, not one in one place and others in different positions on different levers. The cap nebs must be securely fastened in their proper positions and so fixed as not to bind the ends of the rolls. No two adjacent rolls should be in contact. All rolls, with their bearings and working parts, should be perfectly cleaned, well oiled, and easy running, otherwise bad spinning will result.

The top and under clearers must be kept clean and well covered or they will allow the waste to be incorporated in the yarn, which will cause bad work in every succeeding process. These things can only be kept right by system, intelligence, and close attention to duty on the part of everybody concerned.

31. Build of Bobbin.—Badly shaped bobbins may be caused in various ways. If the taper on warp-wind bobbins is too long, it can be remedied by not taking up so many teeth on the builder ratchet at each traverse of the ring rail. Owing to the usual construction of ring frames, the taper on filling frames cannot be varied much, a change in the take-up of the builder not affecting the taper as it does in a warp-wind, but merely changing the diameter of the bobbins.

With a medium traverse, a short taper for warp yarn is better than a long one. The long taper decreases the length of the yarn that can be put on the bobbin and requires more stoppage, as the frame will require more frequent doffing. If the ring rail is not made to run more slowly when changing to finer yarn, the coils cut between one another; on the other hand, if not made to run more quickly for coarser yarn the coils ride on one another and form an uneven surface. If either of these faults is found, the gearing should be changed so as to wind each layer correctly. Bobbins irregularly shaped or with uneven surfaces may be caused by dirty lifter rods, sprung ring rails, or bobbins not fitting on the spindle sleeves properly.

The frames should receive careful attention and should be examined periodically, especially the older machines, to see whether the rings are retaining their proper rotundity and whether they need replacing or turning; whether the cylinders are true; whether the spindles are kept properly adjusted by means of the adjustments provided; that no undue wear is occurring in cylinder bearings, loose pulleys, and other quickly revolving parts; that the steel rolls are in good condition, not having become roughened or scratched by the use of knives or hooks for picking off laps, or loose in their

joints; that they remain straight and true and are not worn in the necks; that ring rails are level and have not sprung from the supports; that bobbins are thrown out when they become damaged or untrue.

Other features that tend to make good yarn are well-balanced bobbins, clean creels, skewers free from waste, proper space between the boards of the creel, and short piecings from creeling.

On filling frames, especially, bobbins should be reamed on the top or the base as soon as it is required so that they will fit the spindles properly. Any waste that collects in the bobbins should be cleaned out so that the bobbins will stand in line, each in its proper place on the spindle.

The work of the frame should be closely watched, and if it is found that excessive breakage of ends occurs at certain times the reason should be ascertained. For instance, if when the frame is winding on the small diameter of the bobbin an excessive amount of breakage is noticed, sometimes a lighter traveler and a higher speed will obviate this, and so on.

Filling frames should not be stopped when winding on the small diameter of the cone, as this causes additional strain and breakage of ends when starting up as compared with winding on the large diameter.

32. When considering production, the speed of the front roll is the most important factor. The speed of the spindle must also be sufficiently high to give the necessary turns per inch to the yarn while the front roll is running at a good speed, but it should not be so high as to cause breakages and necessitate excessive spindle speed to make the work run well. The speed to adopt can be found by experimenting until one is attained that gives the greatest production with the least amount of work for the spinners.

33. Economical Management.—A large production means economy, as it reduces the cost per pound of the yarn. It is therefore more economical to run at high speeds than low if the product is maintained of good quality.

Economy of power is maintained by not having too high a tension on the spindle bands and by having all parts of the frame well oiled.

One of the greatest expenses in connection with ring frames is the matter of travelers, which amounts to an average of about $20 per thousand spindles for the first year, but should not be more than $6 to $8 per thousand afterwards. In some cases the figures given are exceeded in the first year. One method of economizing on travelers is to have the speed of the spindles and the weight of travelers so proportioned that the travelers will not heat and lose their temper, thus wearing out and flying off, but of equal, if not greater importance, is it to use rings made of high-grade steel, or what are often spoken of as *fine-grained rings*.

It is, of course, economical to use cotton that is not too high in price to produce the results desired in the yarn, but it is just as true that it is false economy to use too poor a quality of cotton. By selecting cotton of too low a quality the production of the frame is reduced, there are more breakages of yarn, more stoppages, and the quality of the product is not so good as it ought to be. By using a sufficiently good quality of raw material the yarn can be spun with less turns per inch than when made from poor cotton, thus increasing the production and making a better appearance in the fabric. It is especially true with regard to yarn for weaving that sufficiently good cotton should be used, as a good quality of yarn helps to increase the production in the weave room, reducing the number of times that the loom stops and reducing the waste as compared with what is the case when poor yarn is used.

34. Atmospheric Conditions.—The temperature of the spinning room should be between 70° and 80°, the finer yarns requiring the higher temperature, the coarser yarns the lower temperature. Warm rooms mean easier running spindles, as the bands are not so tight and are more pliable; the oil in the spindle reservoirs is warmer; and the fibers of cotton more tractable and more easily drawn; 75° is a good

standard. Means should be taken to keep the temperature at this standard by an efficient system of heating and ventilating.

The amount of moisture contained in the air of the spinning room, spoken of as the *humidity*, is of importance. In some cases the proper humidity is obtained by forcing steam into the spinning rooms, but this is not good practice, as it heats the room unnecessarily and undesirably. It is much better to use an artificial system of moistening the air by which cold vapor is forced into the room. By means of these moistening machines, sometimes called *drosophores*, finely divided sprays of cold water are produced, thus attaining the requisite standard of humidity without an undesirable increase in temperature. This is especially advantageous in hot weather. It is generally found that a standard humidity of from 50 to 60 per cent. of the maximum amount of moisture that the atmosphere will contain gives the best results. Temperature and humidity should not be confused. **Temperature**, of course, means the number of degrees of heat, while **humidity** means the amount of moisture in the atmosphere.

SETTING UP AND RELEVELING NEW AND OLD FRAMES

35. In setting up new spinning frames and also in going over old ones and resetting them, which should be done at least once a year, a number of precautions are necessary, especially in connection with the setting of the spindles, rings, and cylinders. As the spindle rail and the ring rail should be leveled accurately, the whole frame should be accurately set up and leveled in the mill, and later if the floors settle, in the case of a new mill, it should again be leveled. After the spindle rail has been leveled, the spindles should be set plumb and their tops leveled perfectly; if they are well made, this ought to be possible without packing them with paper, although this is sometimes necessary, especially with old frames. The object of having the spindle vertical is that it shall be concentric with the ring, not only at the bottom of the traverse but at the top as the

ring rail moves vertically. The spindle rail is bored with a hole larger than the lower portion of the bolster to allow for adjustment, but the spindles should be set as nearly as possible in the center of this hole, so that all will be in line. This keeps the bands all one length.

The lifting rods should be vertical and the ring rails should fit accurately on the top of the lifter rods without having to be sprung into position. After the ring rail is placed in position the rings should be adjusted to the spindles so that they will be perfectly concentric, whether the rail is at the top or at the bottom of the traverse. All adjustments should be confined to the rings if possible. All rings should be set with the spindles running; where the cast-iron holder is used they are set by means of three screws—two at the front and one at the back. By slackening one or more of these screws and tightening the others, the ring can be moved in almost any direction. Where the plate holder is fixed to the ring rail by means of screws binding in only two slots, the adjustment can only be made backwards and forwards, or in two directions.

The guide wires should deliver exactly over the tops of the spindles. Too much care cannot be taken in the setting of these guides, since if not centered they cause the yarn to chafe on one side of the bobbin, thereby causing a great deal of breakage. The best method of setting them is by means of a tapered set made of steel. A hole about $\frac{1}{2}$ inch deep just fits the spindle, while the point just touches the guide. The spindle should be running while the guide wire is being set.

Most modern frames have arrangements for setting the cylinder higher or lower as required, so as to bring the bottom of the groove on the whorl exactly level with the center of the cylinder shaft. Cylinders should be exactly straight throughout their whole length. Adjustments should be provided so that the cylinder may be moved to accommodate any position of the spindle; also, that the correct distance between the guide wire and the top of the spindle may be obtained. In some frames this setting is provided for by arranging for the thread board to be moved vertically.

The fact that the frame itself, including sampsons, head-ends and foot-ends, should be perfectly level must again be emphasized; otherwise, settings cannot be made accurately or if they are they may later work out of true. Unless well constructed, all joints milled so as to fit closely together and all made accurately to the same templet, the frame cannot be expected to remain in good condition and the accuracy of all its settings be maintained.

COTTON MULES

(PART 1)

MULE CONSTRUCTION

INTRODUCTION

1. Cotton Spinning.—The **spinning** process in the series of cotton-yarn preparation processes is the final one and converts the material into yarn. Previous processes have cleaned the fibers, arranged them in suitable formation as roving, and attenuated this roving until only one more process of drafting is necessary to reduce it to the size desired to form yarn. At the spinning process this final attenuation is imparted, and in addition a sufficient amount of twist is permanently inserted to give to the yarn the strength desired for the purpose for which it is intended. It is in this respect, especially, that the spinning process differs from those preceding it; in the previous processes twist is inserted only because it is necessary to enable the raw material to hold together while being handled and operated on at the various processes.

2. Cotton yarn is spun on four kinds of spinning machines —the hand mule, the throstle frame, the self-acting mule, and the ring frame. The term *frame spinning* includes spinning by both ring frames and throstle frames, but is now generally applied only to ring-frame spinning. The term ***mule spinning*** includes both self-acting and hand-mule spinning, but is now generally applied only to self-acting-mule spinning.

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The hand mule is fast disappearing, in consequence of the great improvements made in the self-acting mule, and is now used in the cotton trade only for spinning very fine numbers in the older manufacturing countries. It is so arranged that the heavier parts are driven by power, but the winding and other motions requiring careful adjustment are governed by hand.

The throstle frame is also passing into disuse, in consequence of the greatly superior advantages of the ring frame, so that the two leading machines now in use for spinning cotton yarn are the ring frame and the self-acting mule.

3. Comparison of Ring Spinning and Mule Spinning.—The chief difference between the ring spinning frame and the mule is that the former is a constant, and the latter an intermittent, spinning machine. While the ring frame is in operation, yarn is continually being delivered by it; but while the mule is in operation, a few seconds are occupied in drawing out and twisting the roving, so as to produce a certain number of inches of yarn, after which the machine ceases to produce and another brief period of time is occupied in winding on to the spindles the yarn that has been spun. This complete cycle of operations is repeated several times a minute.

There is also a difference in the form in which the yarn is produced. The ring spinning frame winds it on a wooden or paper bobbin, while the mule produces yarn in the form of a cop; that is, a cylindrical coil of yarn with cone-shaped ends, self-contained by means of the method of winding, which can build up the yarn on the bare spindle of the mule firmly enough to be handled, after removal, without requiring any central support, although more commonly the cop is built on either a short or a long paper tube.

In the mechanism by which the yarn is produced, the ring spinning frame differs very considerably from the mule; in fact, the two machines are radically different in principle, construction, and operation. The mule is far more complicated, more liable to disarrangement, and requires greater

skill in operating and supervising. As a rule, it is used in the United States to produce only certain classes of yarn for which it is especially suitable; for example, fine yarns for filling, soft-twisted yarns for knitting, and very coarse yarns made from short-staple cotton, from mixtures of cotton and waste, or from waste alone.

The relative advantages of the mule and the ring spinning frame are debatable and depend on local or special conditions in many cases. In general, it may be stated that the mule has the advantage for special classes of yarn, such as those named, largely owing to its great range of adjustments, which enables almost any desired effect in cotton yarns to be produced. In the amount of power required per spindle the mule has the advantage over the ring frame and also, except in special cases, in the first cost of the machine per spindle. As regards the cost per pound of production, the mule has the advantage on very fine numbers, and in some cases on very coarse numbers, the ring frame having the advantage on medium numbers, and generally also on coarse numbers.

The disadvantages of the mule as compared with the ring spinning frame are that mules require more highly skilled and more expensive operators than ring spinning frames, that a larger amount of floor space per spindle is necessary, and that they are more easily put out of working order, and, in case of accidents, are more difficult and expensive to repair.

4. The mule is the invention of Samuel Crompton, of Bolton, England, who, about the year 1779, combined the principles of the water frame, which had been invented by Richard Arkwright and was of the continuous type of spinning machine, with the spinning jenny, which had been invented by James Hargreaves and was of the intermittent-spinning type. To this combination of two widely different machines the name mule was applied and has ever since remained in use.

The mule has always been more largely used, in England, for cotton spinning than the ring spinning frame; this is also the case to a considerable extent in other parts of Europe,

but the tendency now is to increase the number of ring spinning spindles. In England, from 35,000,000 to 40,000,000 mule spindles are in operation. The mule is used only to a comparatively small extent, in America, chiefly in the New England and Middle states.

The mule having been invented in England and for over a century having remained the standard spinning machine in that country, it is only natural that the highest developments of mule construction and mule spinning have been in that country, and it is universally recognized that four or five types of mules now built in England represent the highest type of spinning mule that can be found. In general principle these are somewhat similar, the differences in construction being principally in the details of the motions adopted to produce various results.

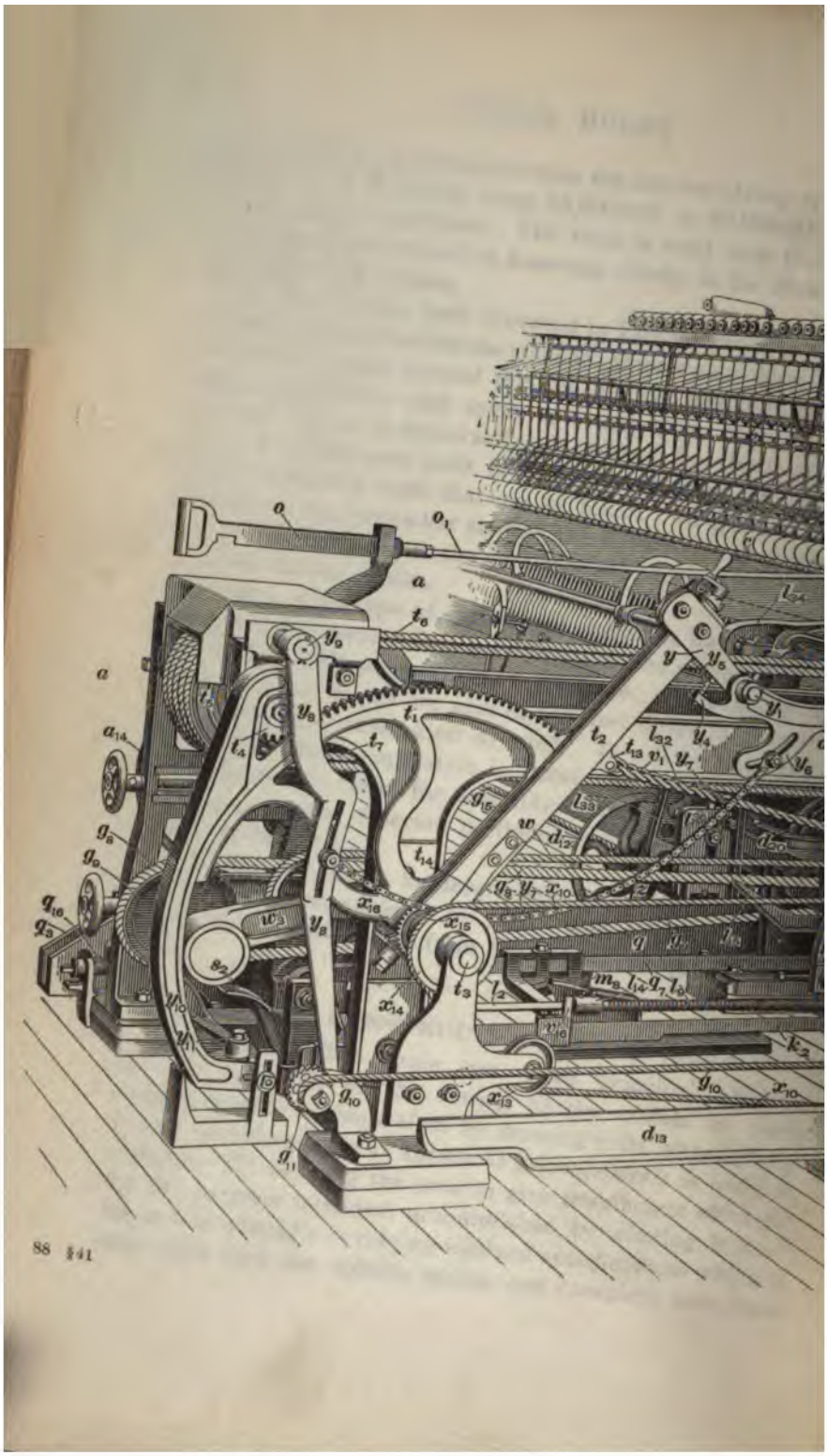
Perhaps in no type of cotton-mill machines have so many different contrivances been used to attain the same object on machines of different makes as in the mule. In consequence, many styles of mules are now in use that differ in construction, but do the same kind of work. It will be impossible to describe here every style in detail, but a standard construction will be taken for description, and if this is studied carefully, slightly different motions on other mules will be easily understood.

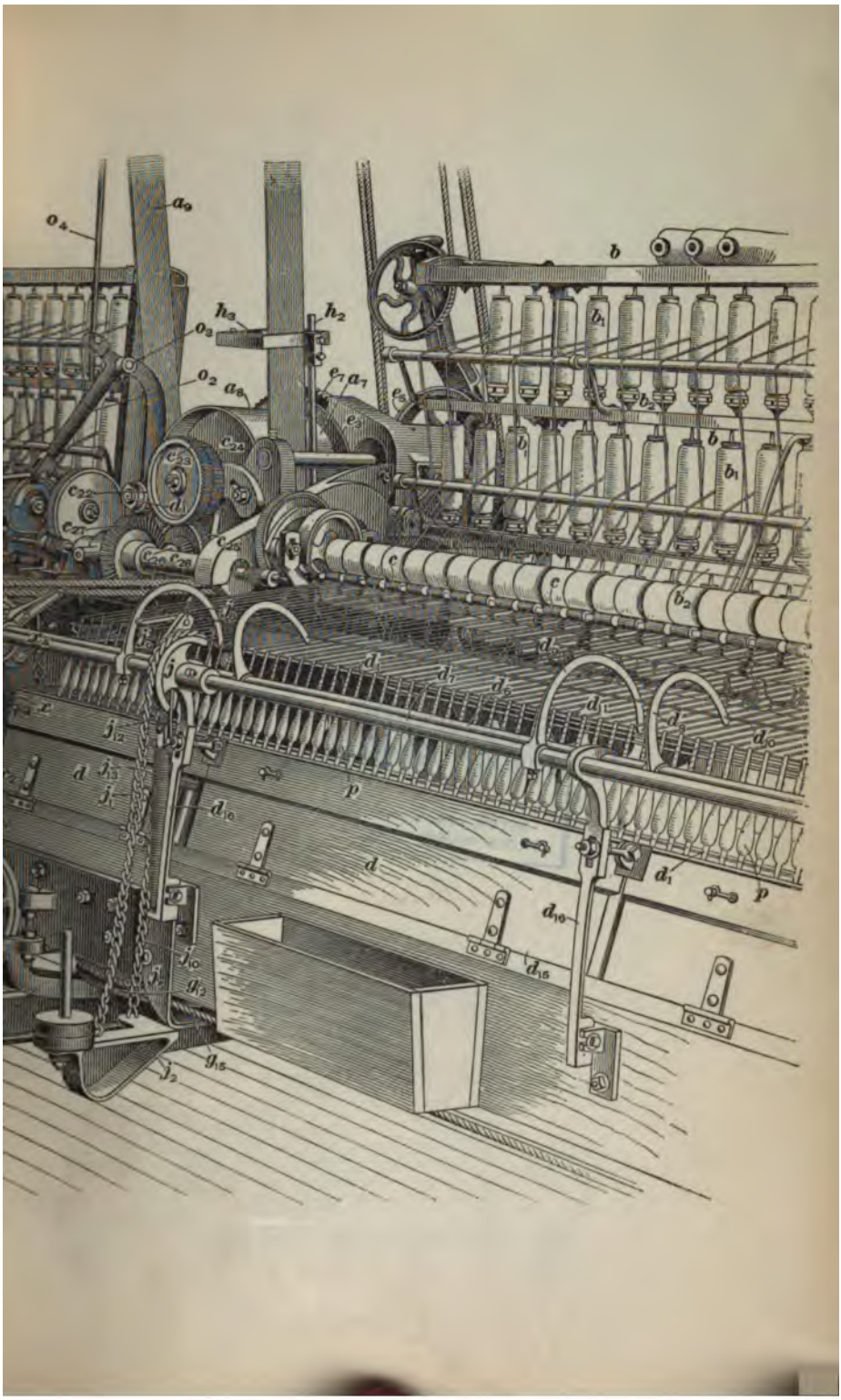
The type of mule to be described is known as a *cam-shaft mule with the rim pulley at the back.* The meaning of these terms will be understood from the description that is to be given.

GENERAL CONSTRUCTION OF THE MULE

5. Objects.—The mule has three principal objects: (1) the reduction of the roving to the counts of yarn desired, usually accomplished by drawing rolls, although on special occasions what is known as *carriage draft* is used in addition; (2) twisting the yarn to give it sufficient strength for the purpose intended, accomplished by winding it near the end of a rapidly revolving inclined spindle, from which it slips each time the spindle makes one complete turn, thus

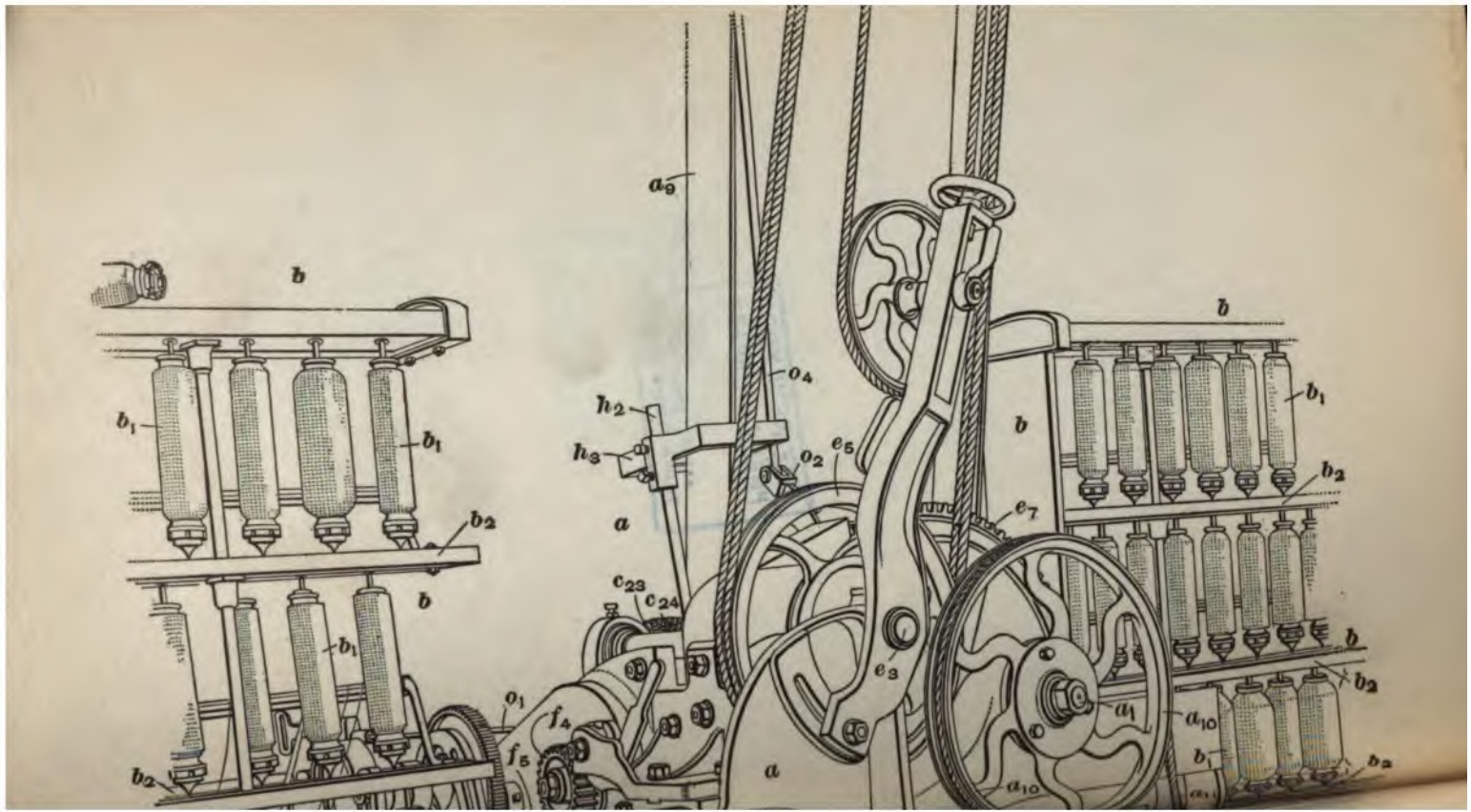


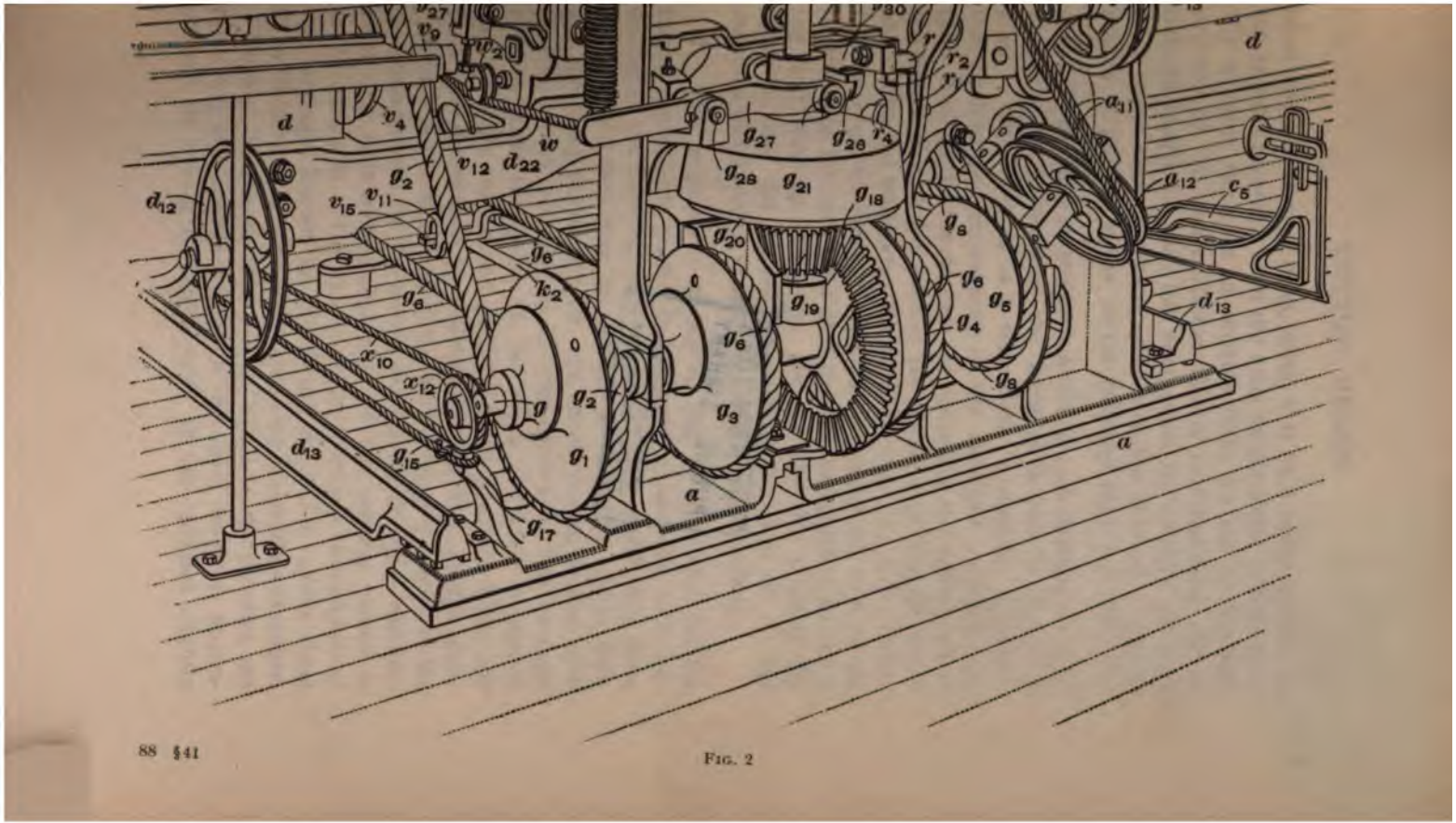

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y8
t6
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t7
t4
t2
y5
y1
y7
y6
l24
l22
l23
l20
w
d12
g8 y7 x10
x16
x15
y8
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m8 l14 q7 l8
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o4
h2
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e3
e5
e7
c23
c24
f4
f5


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v_9
v_{27}
v_2
w
v_{12}
d_{22}
g_2
d_{12}
v_{15}
v_{11}
g_6
k_2
x_{10}
x_{12}
g
g_2
g_1
d_{13}
g_{15}
g_{17}
g_6
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g_{18}
g_{28}
g_{21}
g_{27}
g_{26}
r_4
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r_1
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g_8
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g_5
g_4
g_3
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c_5
d_{13}
a
d

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FIG. 2


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receiving one turn of twist, while it is kept under tension by the spindle receding from the rolls as the stock is delivered; (3) winding the yarn in suitable form for use at the next process or for transportation; this is accomplished, after a definite length of yarn has been spun, by winding the yarn on a paper tube or a bare spindle in the form of a cop by means of guiding wires, as the spindles approach the rolls.

6. Principal Parts and Actions.—A perspective view of the main portions of the front of a mule is shown in Fig. 1, while Fig. 2 is a rear view. Generally speaking, the machine proper consists of the *headstock a*, which contains most of the mechanism for operating the various parts; the *creel b*, Fig. 3, for holding the roving that is to be drawn and converted into yarn; the *drawing rolls* c, c_1, c_2 for inserting the required amount of draft to reduce the size of the roving; and the *carriage d* that carries the spindles for twisting and winding the yarn, the cylinder for driving the spindles, and the fallers for guiding the yarn on to the spindles and keeping it under tension during winding.

7. The bobbins of roving b_1, Fig. 3, from the last fly-frame process are placed in the creel b and the ends conducted to the drawing rolls c_2, c_1, c, through which they pass, in order that they may be drafted as required. After leaving the front drawing rolls, the stock passes to the spindles d_1, which are carried by the carriage. The carriage recedes from the rolls, as the stock is being delivered, but after the rolls cease to deliver, it returns. When the rolls first commence to deliver, the spindles occupy position (a), shown in dotted lines, and gradually recede in the direction shown by the arrow, until position (b) is reached, when the rolls stop delivering and the carriage ceases to move outwards. The extent of the outward movement of the carriage, known as the *draw*, or *stretch*, varies from 53 to 68 inches, the general length being about 62 or 64 inches.

During the outward run of the carriage, the spindles are revolving and inserting twist in the yarn, which is accomplished by having the upper ends of the spindles slightly

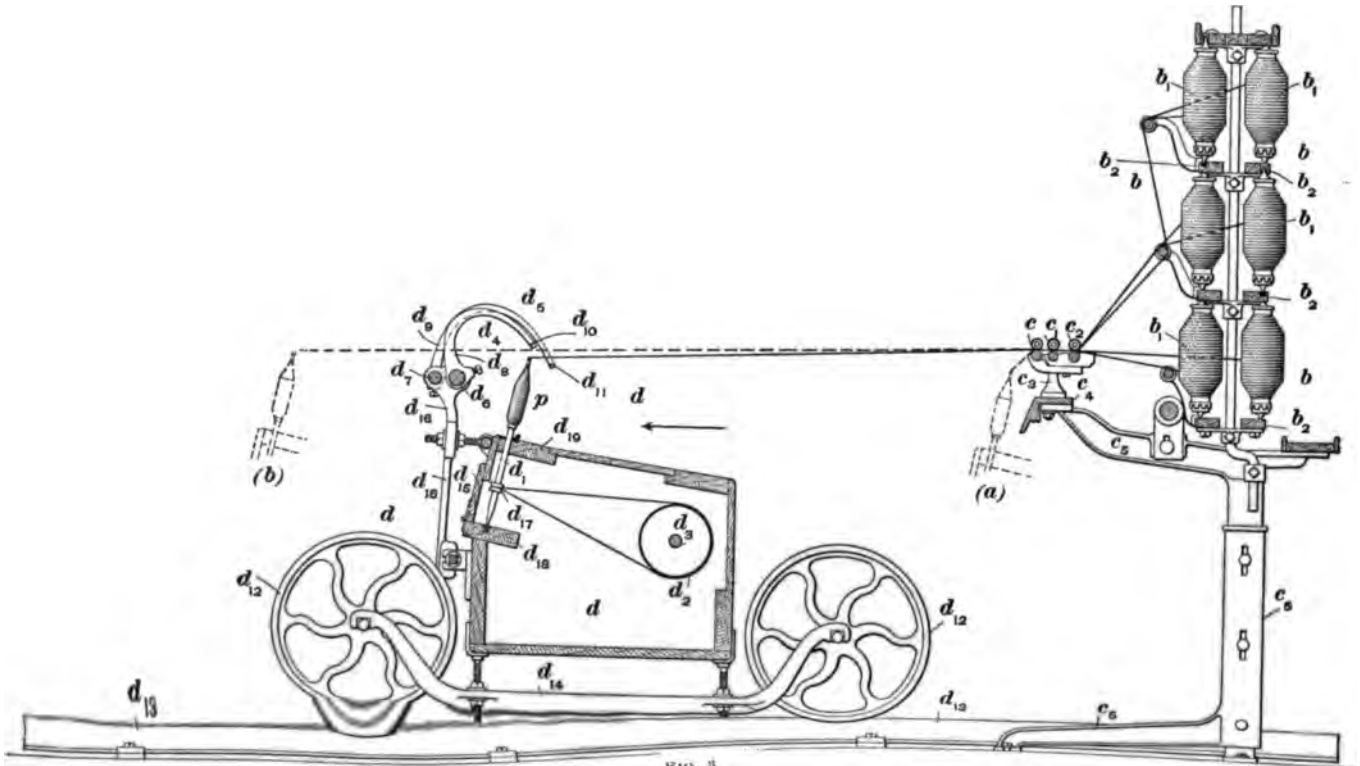

b1
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b
c
c1
c2
c3
c4
c5
c6
(a)
(b)
d
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d2
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d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
p

FIG. 3

below the delivering point of the rolls, as shown by the dotted lines in position (*a*), and the spindles inclined, with the upper end nearer the rolls than the lower. Fig. 4 is a large view showing this arrangement for one spindle, which is the same for all. Since the spindle is inclined toward the rolls and is revolving as the stock is being delivered, a few open spirals of yarn are wound on its blade between the *nose*, or

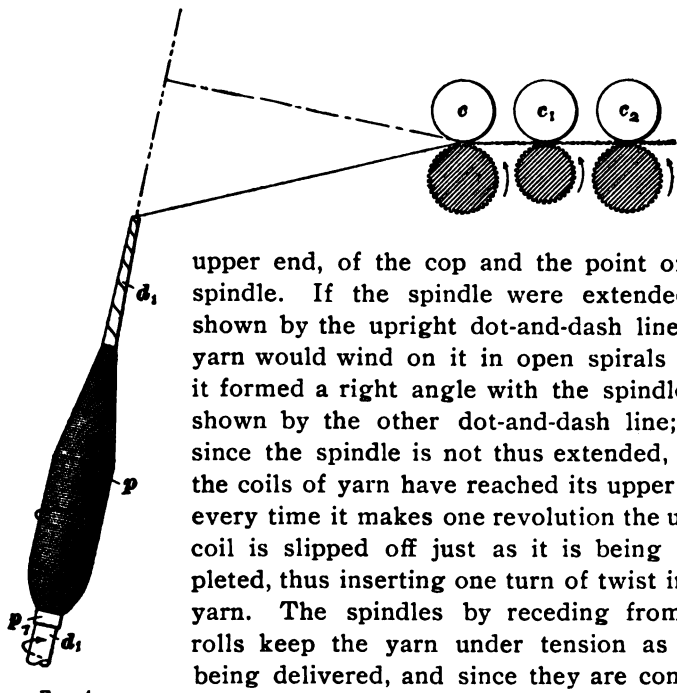


FIG. 4

upper end, of the cop and the point of the spindle. If the spindle were extended as shown by the upright dot-and-dash line, the yarn would wind on it in open spirals until it formed a right angle with the spindle, as shown by the other dot-and-dash line; but since the spindle is not thus extended, after the coils of yarn have reached its upper end, every time it makes one revolution the upper coil is slipped off just as it is being completed, thus inserting one turn of twist in the yarn. The spindles by receding from the rolls keep the yarn under tension as it is being delivered, and since they are continually revolving during this time, they are continually inserting twist. The inclination of the spindles assists in allowing the yarn to pass easily over the ends, especially when the carriage is near the end of its outward run, as the angle between the yarn and the spindles approaches nearer to a right angle than when the carriage is first starting out. This is shown by positions (*a*) and (*b*), Fig. 3. The spindles are driven by bands passing around the revolving cylinder d_1 and the whorls on the spindles.

While the carriage is running out, the fallers d_4, d_5, known as the *winding* and *counter fallers*, respectively, are not in contact with the yarn, but occupy the positions shown in Fig. 3, the winding-faller wire being above the yarn and the counter-, or tension-, faller wire, below. The winding faller is for the purpose of guiding the yarn on to the spindles in the proper form to build up a cop, while the counter faller keeps the yarn under tension during winding. Generally speaking, fallers consist of two shafts d_6, d_7 that carry curved arms, or *sickles*, similar to d_8, d_9 that are arranged at intervals along their respective shafts. At their outer ends these arms support wires d_{10}, d_{11}, which are the portions that come in contact with the yarn.

When the carriage has reached position (*b*), Fig. 3, the spindles and rolls are stopped and the spinning is completed. In order that the yarn may be wound on the spindles, the open coils of yarn between the noses of the cops and the ends of the spindles must be unwound; this is done by causing the spindles to make a few revolutions in the opposite direction to that in which they revolve during spinning and winding, and is known as *backing off*. After the open coils are entirely unwound, the spindles stop revolving in this direction, the fallers in the meantime having assumed their proper positions for winding. Winding commences as the carriage starts to run in and continues, the yarn being guided on to the spindles by the winding faller, until position (*a*) is reached, when the carriage and spindles stop, which completes the cycle of operations. The rolls now begin to deliver, the spindles to revolve, and the carriage to move outwards, as before.

8. The actions of the mule can thus be divided into four principal periods in the order in which they occur: (1) drawing and twisting; (2) backing off; (3) winding; (4) reengaging. These actions are automatic and are repeated at frequent intervals. The amount of time consumed in their repetition varies according to circumstances, such as the speed of the mule, the counts of the yarn being spun, the

length of the stretch, or draw, etc. A greater length of time is required when spinning fine counts, hard-twisted yarns, when running at slow speeds, and when the stretch is long. For convenience and explanation, the time consumed will be considered as 15 seconds; that is, about 15 seconds elapse from the time the drawing and twisting action commences until reengaging is completed and drawing and twisting commence again.

DETAILS OF CONSTRUCTION

HEADSTOCK

9. The **headstock** consists of a rigid, rectangular, iron framework supporting the mechanisms that operate the majority of the various motions necessary in the operation of the mule. It is not situated directly in the center of the mule, but a little to one side, causing the carriage to be in practically two sections, one longer than the other; only a portion of the carriage is shown on each side of the headstock in Fig. 1, but it extends for a considerable distance, in some cases 30 or 40 feet, although this varies with the number of spindles and the gauge of the mule. The headstock contains the *rim shaft*, or main driving shaft, of the machine; the *cam-shaft*, which controls the period of action of the various motions; the frictions for backing off and drawing in; a part of the spindle-driving mechanism; a part of the roll-driving mechanism, etc.

10. The **rim shaft** a_1, shown in the elevation, Fig. 5, and in the plan view, Fig. 6, is the main driving shaft of the machine, as it is through this shaft that the power for operating most of the various parts is transmitted. It is usually driven from the main shaft of the room through a countershaft, as shown in Fig. 5. The main driving shaft a_1 carries a pulley a_2 driving a tight and a loose pulley on the countershaft a_4. When the belt a_3 is on the tight pulley, the countershaft receives motion and consequently drives the mule, as it carries a pulley a_5 driving a tight pulley a_7 on

the rim shaft a_1 by means of a belt a_8. The rim shaft also carries a loose pulley a_9.

11. The **cam-shaft** e, Figs. 6 and 7 (a), (b), (c), and (d), operates and controls the various motions with regard to the time that they are, and are not, in operation. It is situated within and near the back of the rectangular iron framework of the headstock, and is supported from the side of this by brackets, two of which are shown at e_1, e_2. This shaft is driven from the countershaft a_4, Fig. 5, through an auxiliary shaft e_3, known as the *backing-off friction driving shaft*, or frequently as the *taking-in shaft*. The countershaft carries a small band pulley e_4 that drives a band pulley e_5 on the shaft e_3. On the same shaft as the pulley e_5 is a spur gear e_6, Figs. 6 and 7 (a), driving the large backing-off cone-friction gear e_7, which, in turn, meshes with the gear e_8 on the rear end of the cam-shaft; **the cam-shaft** revolves continually.

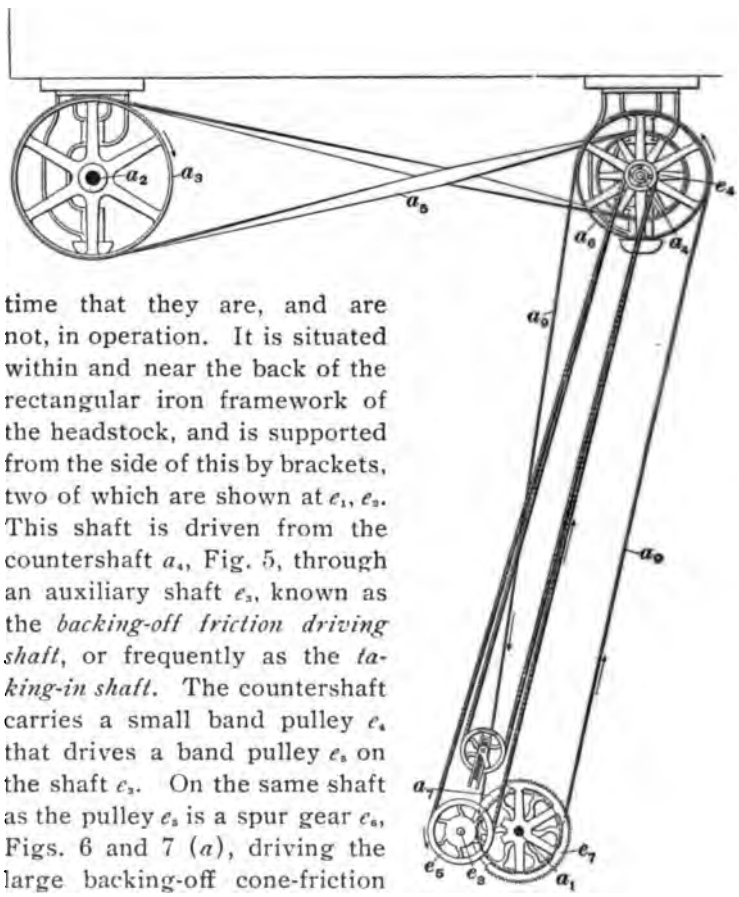


FIG. 5

12. **The Cone Friction.**—A conical disk, or **shell, e_9 is** securely fastened to the front end of the **cam-shaft, while**

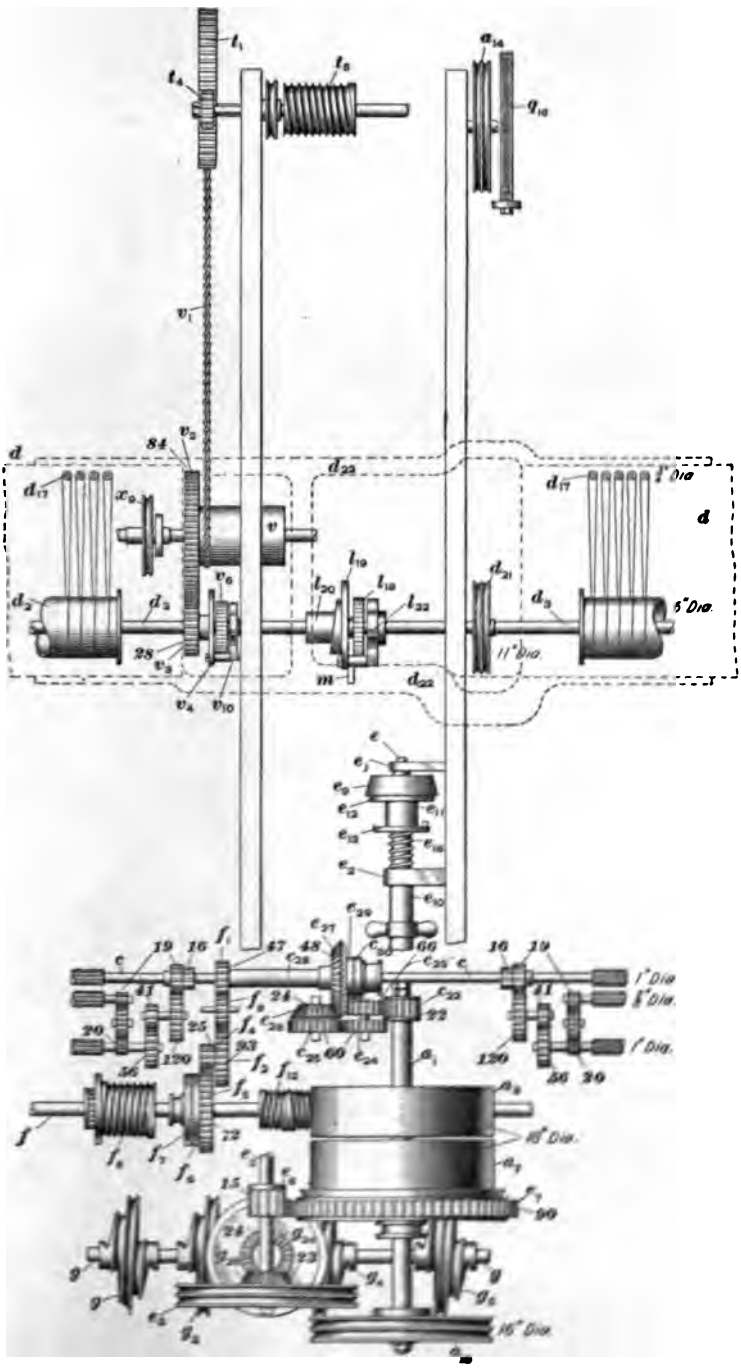


FIG. 6

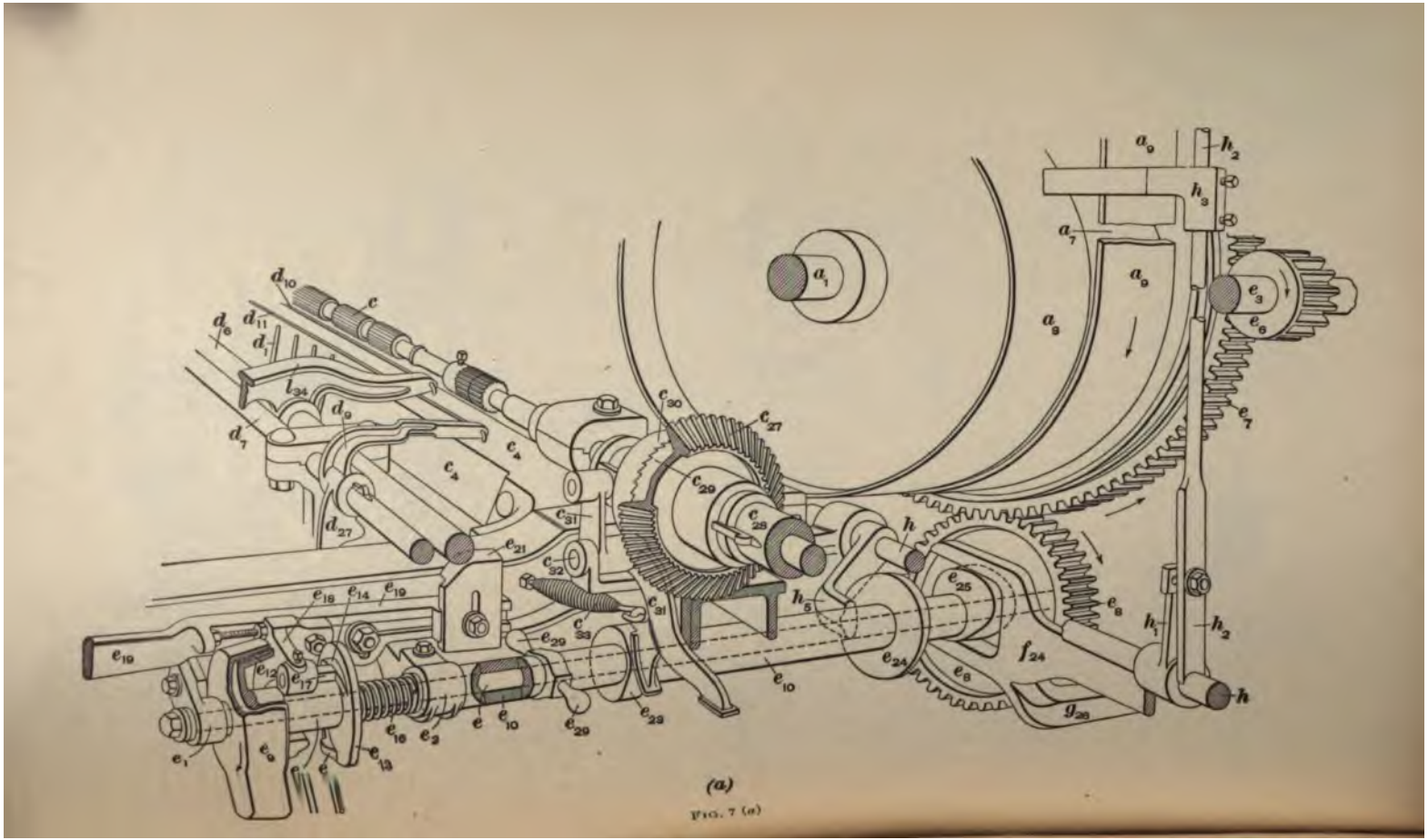
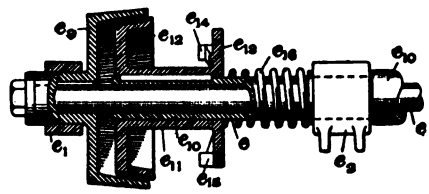


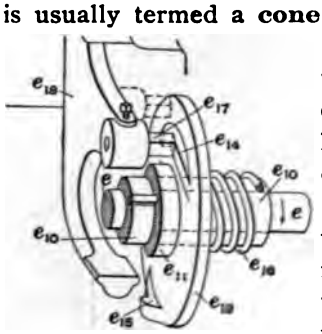
FIG. 7 (a)

extending almost the entire length of the shaft is a long sleeve e_{10} that carries a number of cams. Fig. 7 (*a*) is a perspective view of the cam-shaft with a portion of the connecting and surrounding parts, while Fig. 7 (*b*) is a sectional elevation of a portion of the front end of the shaft showing the method of driving the long sleeve. The long sleeve extends part way into the cone shell e_9, while keyed to it is a short sleeve, or subsleeve, e_{11}. This short sleeve is free to slide along e_{10}, but cannot revolve without imparting motion to the latter. It carries a friction cone e_{12}, the conical surface of which is covered with leather and comes in contact with the inner conical surface of the shell e_9; the friction between these surfaces is sufficient to cause the short sleeve, and consequently the long one, to revolve during the time that they are in contact. This mechanism is usually termed a **cone friction.**



(*b*)

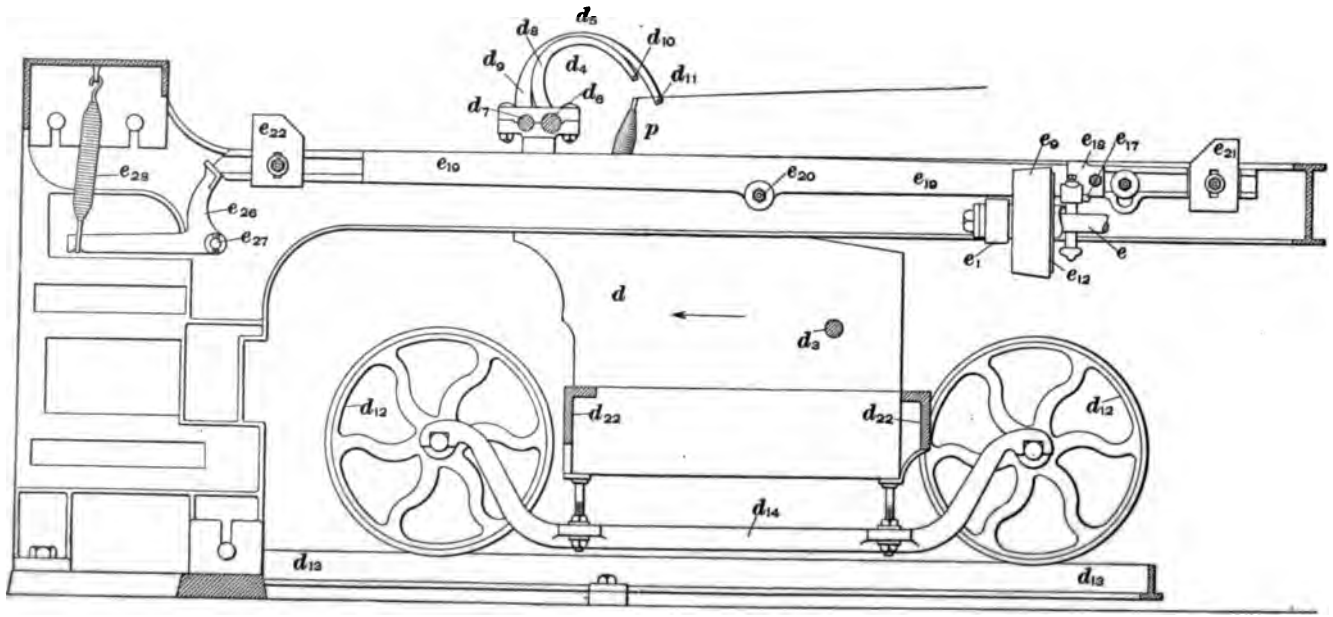
FIG. 7 (*b*)



(*c*)

FIG. 7 (*c*)

In addition to carrying the friction cone e_{12}, the short sleeve carries the circular disk e_{13}, which has two raised portions e_{14}, e_{15}, each having an inclined surface. Fig. 7 (*c*) is a large perspective view of the disk and immediate connecting parts. The short sleeve tends to be pressed forwards by the spiral spring e_{16} so that the cone friction will be thrown into action, but is prevented from moving forwards, until required, by a projection e_{17}, Fig. 7 (*a*), carried by the upper arm of a casting e_{18}, that is in contact with one of the projections on the face of the circular disk e_{13}. The casting e_{18} is carried by a long lever e_{19}, Fig. 7 (*d*), that is pivoted at e_{20} to the side of the framework of the headstock.


d5
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e27
e1
e12
e
d
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d12
d22
d22
d12
d14
d12
d13

(d)

FIG. 7 (*d*)

This lever carries at its rear and front ends castings, or inclines, e_{21}, e_{22}, respectively. These inclines come in contact with the faller shafts, the rear one e_{21} with the shaft d_6, as the carriage runs in, and the front one with the shaft d_7, as the carriage runs out, thus depressing first one end of the lever e_{18} and then the other, the inclines extending upwards sufficiently for this action to take place. Raising the rear end of the long lever removes the projection e_{17} from contact with e_{14}, and causes it to assume the position shown in dotted lines in Fig. 7 (*c*); this allows the spiral spring e_{16} to throw in the cone friction and cause the cam-shaft to turn the long sleeve half a revolution, when the projection e_{18}, being farther from the center of the disk than e_{14}, will come in contact with e_{17}, thus throwing out the cone friction, and stopping the long sleeve, since the short sleeve is forced backwards and the spring compressed by the inclined portion of e_{18}. Depressing the rear end of the long lever throws the projection e_{17} out of contact with e_{18}, allowing the friction to be thrown in and causing the long sleeve to make another half revolution, when the projection e_{14} will come in contact with e_{17}, thus throwing out the friction. These two motions cause the long sleeve to make one complete revolution, which takes place once for every complete cycle of the mule.

In order to hold the long lever e_{18} in position during these changes, its front end is formed with two bevels, as shown in Fig. 7 (*d*), against one of which a spring e_{23} continually forces one of the beveled faces of a locking lever e_{23} pivoted at e_{27}. The movement of the long lever is only slight and is limited by a stud that engages a slot near its rear end. When the front end of the long lever is raised, the rear end must be lowered until the next change takes place, the long lever, in the meanwhile, being held in position by the upper beveled face of the locking lever e_{23} being in contact with the lower beveled face of the long lever, and vice versa when the front end of the long lever is depressed and the rear end raised. The long lever can be operated by hand and the long sleeve turned by the handles e_{29}, Fig. 7 (*a*), thus reversing the parts for setting or adjusting. Depressing the

front end of the lever by hand during the outward run of the carriage causes the carriage to stop until the front end is raised again.

13. The cam e_{33}, Fig. 7 (*a*), operates the front-roll clutch. When the clutch is thrown in, the rolls revolve, and when the clutch is out, they cease revolving. The cam e_{34} operates the belt shipper so that the belt will be on the required pulley at the proper time. The cam e_{35} throws the drawing-in friction in or out, as the case demands. The operation of these motions will be explained later. The cams e_{33}, e_{34}, e_{35} are made in one piece with the long sleeve e_{10}, so that their respective positions cannot be changed. Fig. 7 (*a*) shows the positions of the cams and their adjacent parts just as the carriage is ready to start on its outward run.

CREEL

14. The creel of the mule serves the purpose of supporting the back roving, or stock, that is to be fed into the mule. An elevation of the creel, partly in section, is shown at *b*, Fig. 3; it consists of the necessary number of uprights and brackets for supporting the rails b_3, which, in turn, support the bobbins of roving. The brackets and rails can be adjusted for different lengths of bobbins. Creels are of different types to suit the purpose for which the mule is intended and the place in which it is to be situated.

ROLLS

15. The rolls c, c_1, c_2, Figs. 3 and 8, are for the purpose of drawing the roving to the required size, and are usually of the construction common to fly frames and ring spinning frames. There are three sets of these rolls, the bottom ones being made of steel and finely fluted, while the top ones are generally common leather-covered rolls, except in some cases for spinning very fine yarns, when the front one is leather-covered and the middle and back ones smooth metal without covering.

The bottom rolls are mounted in bearings carried by stands similar to c_3, which, in turn, are carried by the roll beam c_4, supported by stands similar to c_5, Fig. 3. The bearings for the front roll are stationary, while those for the

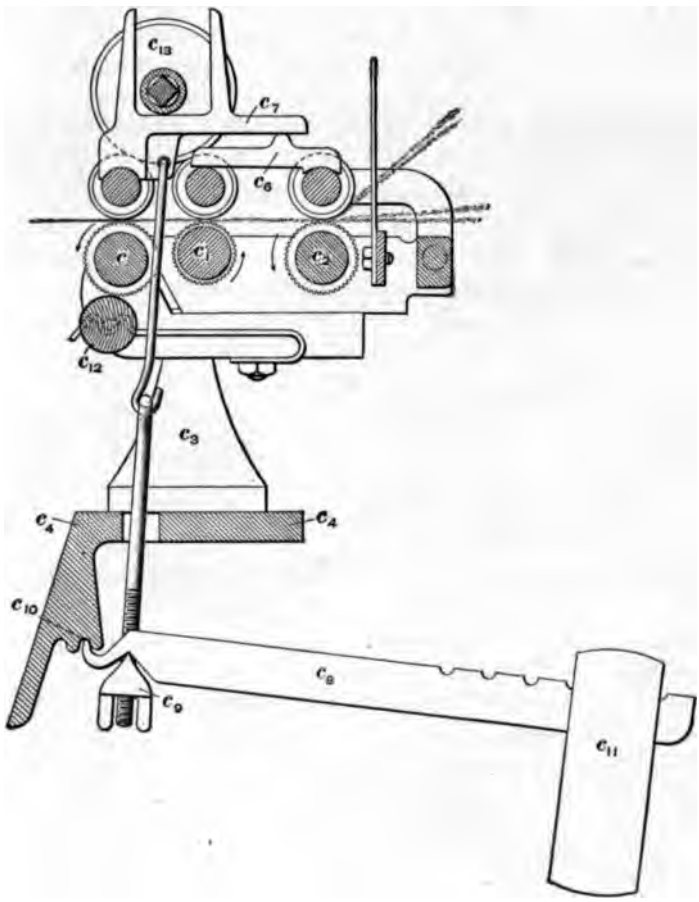


FIG. 8

middle and back rolls are adjustable, in order that the rolls may be set the proper distance apart for the staple being run.

The top rolls are held in position by a series of cap nebs, which are adjustable, in order that the centers of the top

rolls may occupy the proper position with relation to the centers of the bottom rolls. The top rolls are usually long enough for 4 ends of yarn, that is, 2 ends to a boss, although sometimes they are constructed with either 2 or 6 ends to the roll; the lengths of the bosses vary according to the number of ends to the roll, and the counts being spun. Top rolls are usually weighted by means of the saddle-bridle-and-lever system when common rolls are used, except where smooth metal rolls are used at the middle and back, in which cases these rolls are self-weighting, while the front roll is weighted by the dead-weighting system.

Referring to Fig. 8, a short saddle c_6 rests on the middle and back rolls, while a long saddle c_7 rests on the front roll and the raised portion of the back saddle c_6. Attached to the saddle c_7 is a jointed connecting-rod that passes between the first and second rolls, through a hole in the roll beam, and also through an opening in the lever c_9, and carries at its lower end a nut c_8, thereby forming a connection between the lever and itself. The lever is fulcrumed at one end on the roll beam at c_{10}, while the other end carries a weight c_{11} that can be moved along the lever in order to give the amount of weighting required.

When the middle and back rolls are self-weighting, that is, when the rolls themselves are of sufficient size to give the required amount of pressure, the front rolls are usually weighted by the dead-weighting system. Hooks fit on the centers of the rolls and extend downwards, being attached to the upper ends of rods that pass through holes in the roll beam and carry weights at their lower ends. There is one hook, one connecting-rod, and one weight to each front roll.

16. The method of keeping the rolls free from lint, dirt, etc. varies, but the one illustrated in Figs. 8 and 9 is the one generally adopted. The **clearers** for the lower front roll are round, wooden rolls covered with cloth and supported at the ends by springs or weighted levers that keep them pressed against the under side of the roll; a section through one of these clearers is shown at c_{12}, Fig. 8. The top

clearers c_{13} are large cylindrical rolls covered with flannel, and rest on the upper surfaces of the front and second rolls. Each clearer has two bosses and there are as many clearers as top rolls in one line. The front saddles have upright arms that serve as guides for the clearers, which are self-weighting, the necessary weight being given to them by loading their centers with small bar iron.

17. The **traverse motion** for guiding the roving back and forth along the bosses of the rolls is somewhat differ-

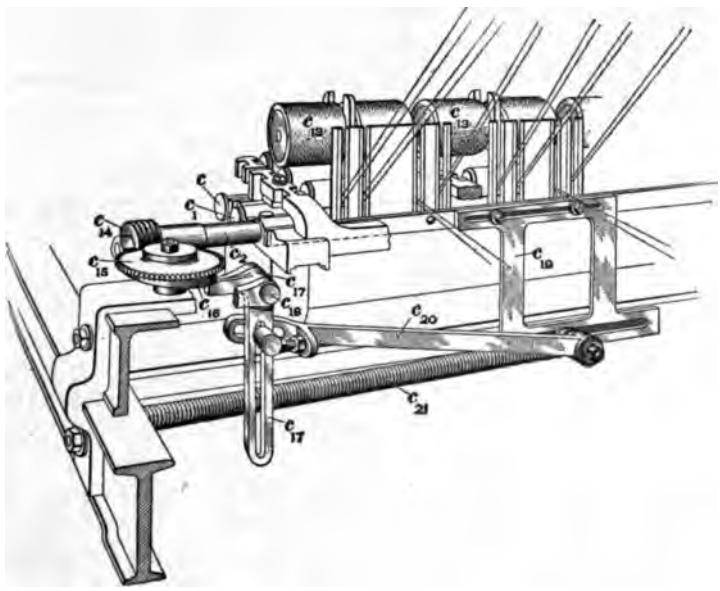


FIG. 9

ent from those generally used on cotton-yarn-preparation machinery. The guides in this case are made of sheet tin, with the edges turned over so as to be rounded where the roving comes in contact with the guide. There is one small sheet for each set of top rolls, with four slots in each sheet for the roving to pass through, since there are four ends of yarn to each set of top rolls. These sheets of tin are supported by a rectangular traverse bar running the full

length of the rolls. This bar is operated from the lower drawing roll c_8, Fig. 9, which carries a single-threaded worm c_{14} driving a worm-gear c_{15} that is compounded with a cam c_{16}. The cam rotating and being in contact with the horizontal arm of the lever c_{17} causes it to swing on its center c_{18}. The traverse bar carries a bracket c_{19} that projects downwards and is connected to the perpendicular arm of the lever c_{17} by means of a connecting arm c_{20}. A spiral spring c_{21} is attached at one end to the framework, while the other end is attached to the bracket c_{19}; this spring tends to draw the traverse bar toward the framework and thus keep the end of the horizontal arm of the lever c_{17} pressed against the surface of the cam. As the cam revolves, it gradually depresses the end of the horizontal arm, which causes the perpendicular arm to swing to the right, and then gradually allows it to rise, which causes the perpendicular arm to swing to the left, thereby imparting a reciprocating motion to the traverse bar and guides.

18. The driving of the rolls is accomplished by the rim shaft a_1, shown in plan in Fig. 6 and in elevation in Fig. 10. This shaft carries a 22-tooth spur gear c_{22} driving a 66-tooth change gear c_{23}. Compounded with the gear c_{23} is a 60-tooth gear c_{24} driving a 60-tooth gear c_{25} that is compounded with a 24-tooth bevel gear c_{26}. This bevel gear drives a bevel gear c_{27} of 48 teeth that is fast on the sleeve c_{28} on the front-roll shaft. The hub of the gear c_{27} forms one-half, c_{29}, of a toothed clutch, the other half of which, c_{30}, is free to slide on the front-roll shaft for a given distance, so that it can be thrown in or out of contact with c_{29}. In Fig. 6, part of the gearing is moved slightly out of its correct position in order that it may be shown more clearly; Fig. 10, however, shows the correct position. The bevel gear c_{27} and the parts c_{29}, c_{30} of the clutch are also shown in perspective in Fig. 7 (*a*). The hub of the part c_{30} of the clutch is hollow, and is prevented from turning on the front-roll shaft by means of two lugs on the inside that engage with slots in the arms of a dog that is keyed to the shaft. Thus c_{30}, although free to

slide on the shaft, cannot revolve without imparting motion to the latter, and consequently, when in contact with c_{28}, which is driven from the rim shaft, it causes the front-roll

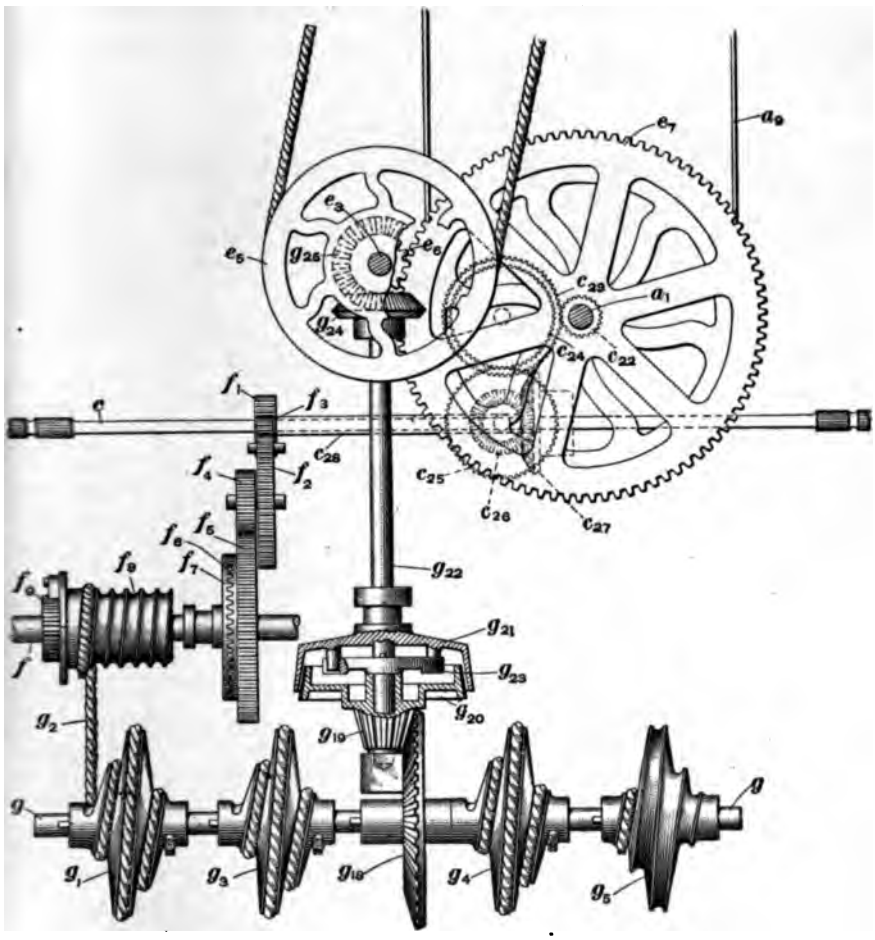


FIG. 10

shaft to revolve. The front roll drives the back roll and the back roll drives the middle roll in the usual manner.

CARRIAGE

19. The **carriage** *d*, Fig. 3, is that portion of the mule that travels back and forth during the operations of spinning and winding. Its object is to keep the yarn under tension, usually just enough to prevent the ends becoming slack, and to carry the necessary parts to assist in these operations. It carries the tin cylinder, or drum, for imparting motion to the spindles; the spindles for twisting and winding the yarn; the fallers for guiding the yarn on to the spindles; and the necessary parts for putting, or assisting in putting, various motions in or out of operation. The general appearance of the body of the carriage is that of a long, five-sided, wooden box with certain attachments, although it might be considered, in a general way, as being rectangular, the whole being mounted on wheels, similar to d_{13}, working on carriage slides, or tracks, similar to d_{12}. At intervals throughout the length of the carriage are castings, similar to d_{14}, to the central part of which the body of the carriage is directly attached, while the ends of these castings extend outwards and terminate in bearings for the wheels d_{13}. The number of slides, wheels, etc. depends on the length of the mule, there being enough to properly support the body of the carriage. The body is built with the necessary braces, etc., so as to be practically rigid in itself; the central part and ends are cast iron.

The front of the carriage is made in three principal sections—the lower and upper casings and the doors d_{15}. These doors are to facilitate the banding of the spindles and the oiling of their footsteps, and are made in short lengths, as shown in Fig. 1. Attached to the upper part of the carriage and lower casing are brackets, similar to d_{16}, that extend upwards to form bearings, or supports, for the faller shafts d_6, d_7.

20. The **cylinder** runs the full length of each section of the carriage, being made in sections and mounted on a shaft d_8 known as the *cylinder shaft*, which is supported at

regular intervals by bearings, or brackets. The cylinder is usually about 6 inches in diameter, is made from heavy sheet tin, and carries bands passing around the spindle whorls, thus driving the spindles.

21. Construction of Spindles and Method of Driving.—The spindles are long, slender, steel shafts, one of which is shown at d_1, Figs. 3 and 11, carrying a whorl d_{17}. The lower portion of the spindle is tapered so as to offer but very little resistance to its rotation, while the upper portion tapers, gradually, from about $\frac{5}{16}$ inch, a little more than midway up the spindle, to about $\frac{1}{8}$ inch near the end, the extreme end being rounded conically so as to offer very little resistance to the yarn in slipping off the point while twisting. The lower parts of the spindles rest in footsteps carried by the step rail d_{18}, Fig. 3, while they are held in an upright position by means of bolsters carried by the bolster rail d_{19}. The bolsters are a little more than midway up the spindles, the taper of the upper portion of the spindles commencing at the top of the bolsters.



FIG. 11

The spindles are not vertical, the upper ends being inclined slightly toward the rolls, producing what is generally called the *bevel* of the spindles. The amount of inclination depends on the counts of the yarn being spun, fine yarns requiring more inclination than coarse ones, as the yarn is weaker. The inclination of the spindles from a perpendicular line erected at the base of the spindles is about 4 inches for a 16-inch spindle when spinning medium counts, say 20s to 40s filling. The inclination for spindles of other lengths runs in about the same proportion for similar counts; that is, about $\frac{1}{4}$ inch for every inch in the length of the spindle.

22. The **gauge**, or the distance between the center of one spindle and the center of the next, varies according to the class of work for which the mule is intended. Coarse yarn is greater in diameter than fine yarn; therefore, in

order that a reasonable amount may be formed into a cop, a greater gauge is required, since the cops are larger than those for fine yarn. Mules intended for spinning warp yarn have a greater gauge than those intended for spinning filling yarn of practically the same counts, as there is a limit to the size of the cop that can be placed in the shuttle of the loom, while there is practically no limit to the size of cops of warp yarn, except that consistent with proper formation and handling. The greater the gauge, the larger is the cop that can be formed.

Mules are made of almost any reasonable gauge, but the standard maximum gauge for general work is about 2 inches, and the minimum $1\frac{1}{8}$ inches; of course, waste spinning, etc. requires a greater gauge. The number of spindles is a variable factor and depends on the class of yarns to be spun, the gauge required, the size of the room, the arrangement of the mules, etc. About the greatest number of spindles to one mule is 1,600, $1\frac{1}{8}$-inch gauge, and the smallest about 300, any required gauge.

23. The spindles are driven from the rim shaft during spinning and backing off, but from a different source during winding. The rim-shaft method of driving is shown in Fig. 12, while the other method will be explained under winding. Referring to Fig. 12, the rim shaft a_1 carries the rim pulley a_{10}, which is a double-grooved sheave pulley driving, by means of the rim band a_{11}, the cylinder d_3. The band passes down from the rim pulley, around the guide pulley a_{12} supported by the headstock, forwards around another guide pulley d_{30}, and thence around the pulley d_{31} on the tin cylinder shaft. The guide pulley d_{30} is supported from the *carriage square*. From the pulley on the cylinder shaft the band passes to the front of the headstock and around the guide and tension pulley a_{14}, thence backwards and around the guide pulley a_{13}, and upwards to the rim pulley. The guide pulley a_{14} can be moved forwards or backwards by the handwheel and screw, in order that the proper tension may be put on the rim band a_{11}.

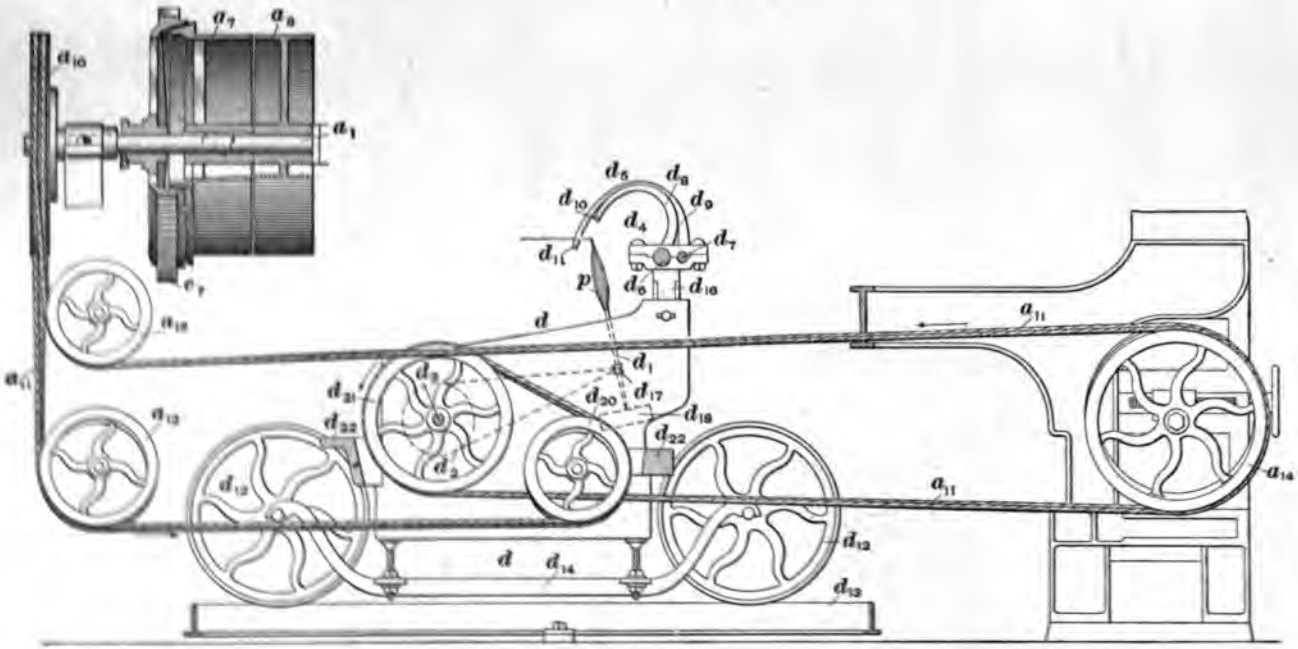
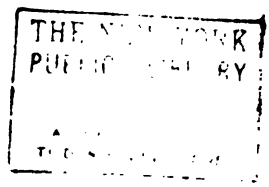

a_7
a_8
a_{10}
a_1
a_9
a_{16}
a_{15}
a_{13}
d_{12}
d_5
d_8
d_{10}
d_9
d_4
d_7
d_{11}
p
d_6
d_{10}
d
d_1
d_{21}
d_3
d_{20}
d_{17}
d_{18}
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d
d_{14}
d_{13}

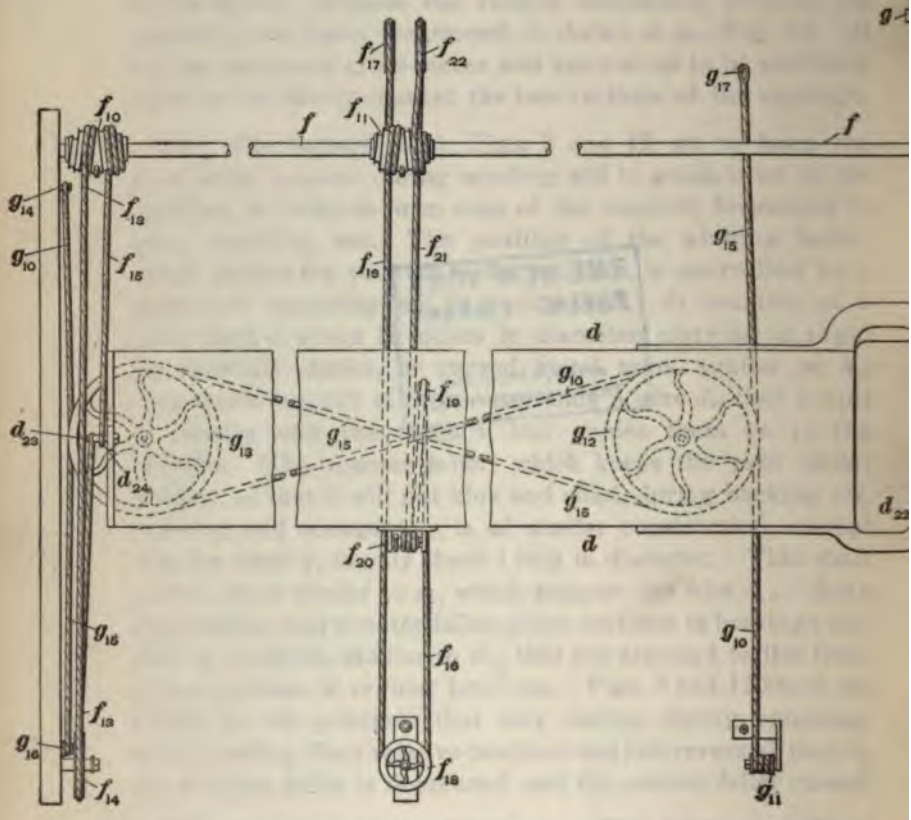
FIG. 12

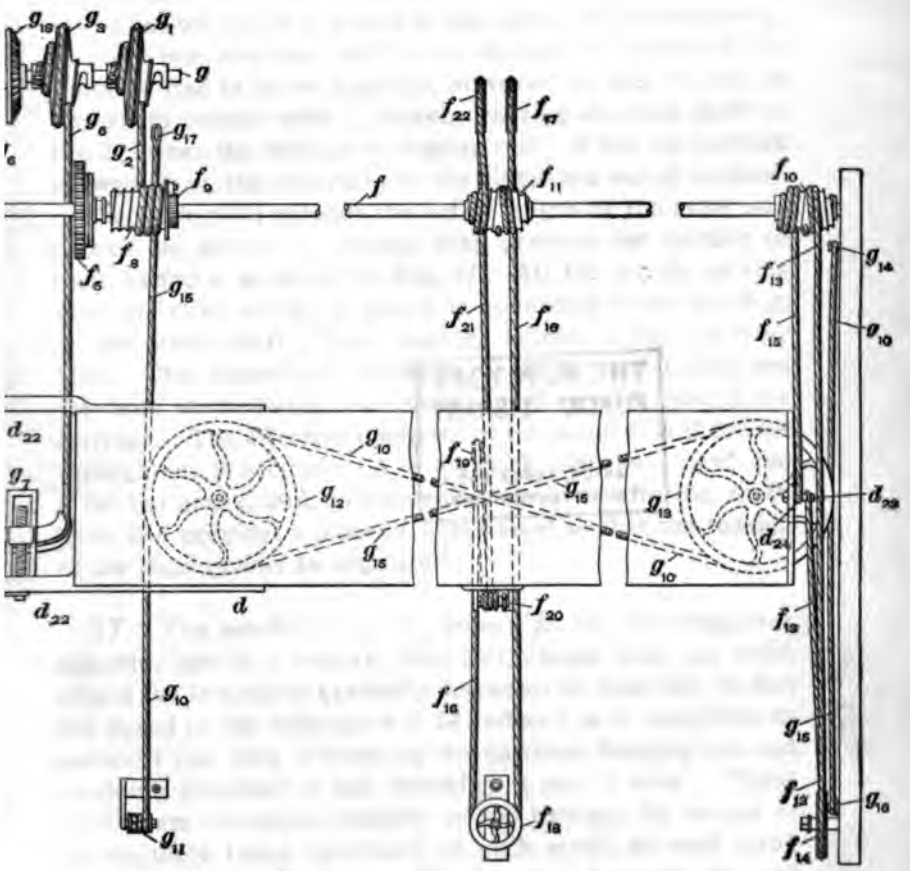
24. The **carriage square** is that portion of the carriage that lies directly within the headstock, and serves to carry part of the mechanism for driving the spindles during the various periods in the action of the mule, locking devices, etc., and to connect the two sections of the body of the carriage that are on either side of the headstock. A top-plan view of the square, without the various mechanical devices for operating the parts mentioned, is shown at d_{22}, Fig. 13. It has the necessary cross-pieces and arms so as to be perfectly rigid and to firmly connect the two sections of the carriage.

25. The **fallers** d_5, d_6, Figs. 3 and 12, are to keep the yarn under tension during winding and to guide it on to the spindles, in order to form cops of the required formation to stand handling, etc. The position of the winding faller, which guides the yarn on to the spindles, is controlled by a small roll operating on an inclined rail. It consists of a steel shaft d_6 about $1\frac{3}{8}$ inches in diameter, carrying at regular intervals sickles, or curved metal arms, similar to d_9; these arms support at their outer ends a wire d_{10} that comes in contact with the threads, and guides them on to the spindles. The counter faller, which keeps the yarn under tension, so that it will not kink and snarl, during backing off, winding, and reengaging, is of similar construction, except that the shaft d_7 is only about 1 inch in diameter. This shaft carries arms similar to d_9, which support the wire d_{11}. Both the winding- and counter-faller shafts oscillate in bearings carried by brackets, similar to d_{16}, that are attached to the front of the carriage at regular intervals. Figs. 3 and 12 show the fallers in the positions that they occupy during spinning; when winding, their relative positions are just reversed; that is, the winding faller is depressed, and the counter faller raised.

26. Driving of the Carriage.—The driving, or drawing out and in, of the carriage d, is accomplished principally by bands and scrolls. It is operated from two sources—the back shaft and the scroll shaft. The back shaft f, Figs. 6 and 10, is driven from the front roll c by a train of gears as follows: The front roll carries a spur gear f_1 of 47 teeth


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f_{17}
f_{22}
f_{10}
f_{11}
f
g_{17}
f
g_{14}
f_{12}
g_{10}
f_{15}
f_{16}
f_{21}
g_{15}
d
g_{10}
f_{19}
d_{23}
g_{13}
g_{15}
g_{12}
d_{24}
g_{15}
d_{22}
d
f_{20}
g_{16}
f_{16}
g_{10}
f_{13}
g_{16}
f_{18}
f_{14}
g_{11}


g_{16} g_3 g_1 g
g_6 g_2 g_{17}
f_6 f_5 g_{15}
f_{22} f_{17}
f f_{11}
f_{21} f_{19}
f_{10} g_{14}
f_{13} f_{15} g_{10}
d_{22} g_7 g_{12} g_{10} g_{15}
f_{19} g_{16}
g_{13} d_{23} d_{24} g_{10}
d_{22} d f_{20} f_{13}
g_{10} f_{16} g_{15}
g_{11} f_{18} f_{12} g_{16} f_{14}


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driving the gear f_8 of 93 teeth through a carrier gear f_9. Compounded with the gear f_8 is the 25-tooth gear f_4, which, in turn, drives the 72-tooth gear f_5 on the back shaft f. The gear f_5 and one-half, f_6, of a toothed clutch with which it is compounded are both loose on the back shaft. The other half, f_7, of the clutch is keyed to the shaft, and consequently, when it revolves the shaft must revolve; this part of the clutch is free to move laterally, however, so that it may be thrown in contact with f_6, thereby causing the back shaft to revolve when the carriage is running out. When the carriage is running in, the two parts of the clutch are out of contact.

The back shaft extends the entire length of the mule and carries six scrolls, or drums, with grooves cut spirally in their surfaces, as shown in Fig. 13. All the scrolls on this shaft are alike except f_6, which is connected to the scroll g_1 on the scroll shaft g by a band g_2, known as the *steadying band*. This connection serves to steady the scroll shaft and the back shaft during the outward and inward runs of the carriage. The effective diameter of the scroll f_6 is the same throughout; it is connected to the back shaft by a pawl and a ratchet gear f_6 and, consequently, revolves with the shaft. This also provides a place of adjustment so that the tension of the band g_2 may be regulated.

27. The scrolls f_{10}, f_{11}, f_{12}, known as the **drawing-out scrolls**, are of a uniform diameter except near the ends, where the last spiral gradually decreases in diameter, so that the speed of the carriage will be reduced as it completes its outward run, thus preventing the carriage banging out and avoiding straining it and throwing it out of true. These scrolls are connected directly to the carriage by means of bands, there being two bands to each scroll, as each scroll is actually a double one. The banding between the end scrolls f_{12} and the carriage, and the banding between the center scroll f_{11} and the carriage is similar.

Fig. 14 is an end elevation giving a side view of the banding connections between the end of the carriage d and the scroll f_{12} on the back shaft. Referring to Figs. 13 and 14, a

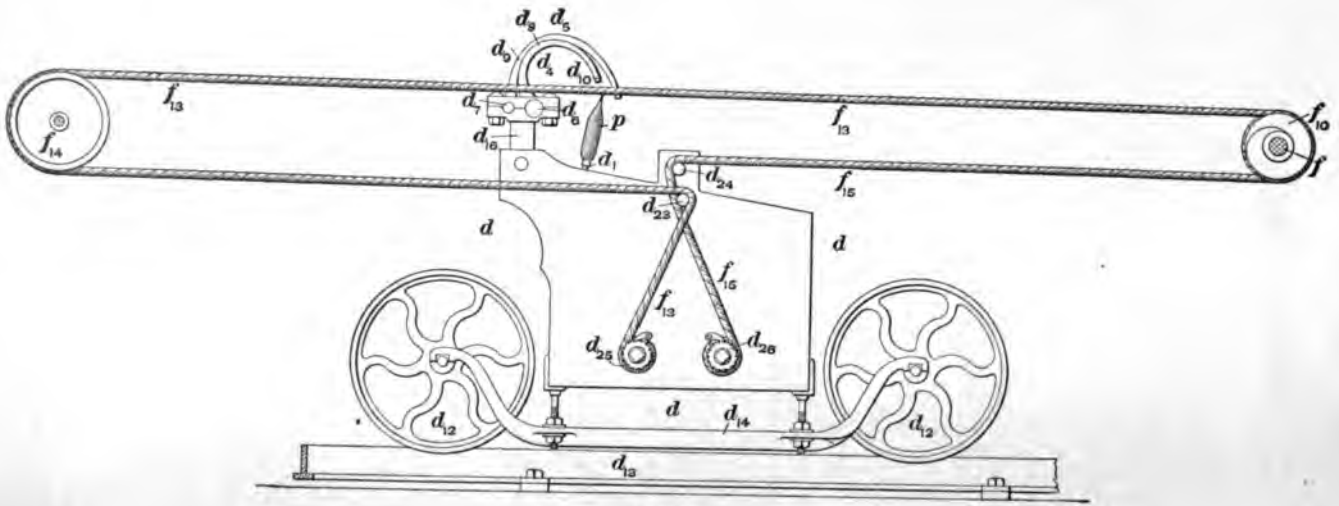

d_3 d_5
d_9
d_4 d_{10}
f_{13}
d_7 d_8 p
d_{16}
d_1
f_{14}
f_{13}
f_{10}
f
d_{24}
f_{15}
d_{23}
d
d
f_{15}
f_{13}
d_{25} d_{26}
d_{12}
d d_{14}
d_{12}
d_{13}

FIG. 14

band f_{13}, attached at one end to the center of the scroll f_{10}, winds over and around the scroll a number of times, and then passes forwards and around a guide pulley f_{14}, thence backwards and around a stud d_{23} attached to the end of the carriage, and downwards to the hub of the ratchet gear d_{25}, Fig. 14, to which the other end is attached. A band f_{15}, Figs. 13 and 14, is attached at one end to the small end of the other section of the scroll f_{10}, winds under and around the scroll, then passes forwards to a stud d_{24} on the carriage end, and thence downwards to the hub of a ratchet gear d_{26}, Fig. 14, to which the other end is attached. The ratchet-gear arrangement is only a device for taking up any reasonable amount of slack that may be caused in the bands during the operation of the mule. When the carriage runs out, the band f_{15} winds up on the scroll and the band f_{13} unwinds, and vice versa.

The scrolls f_{11}, Figs. 13 and 15, are connected to the carriage in a somewhat similar manner, and each is situated about midway between the end of the carriage and the headstock. The band f_{16} is attached at one end to the center of the scroll f_{11}, passes under and around the scroll a few turns, then down and backwards around a guide pulley f_{17}, thence down around a guide pulley near the floor, and forwards around a guide pulley f_{18} supported by a bracket attached to the floor at the front of the machine; it then passes backwards around a guide pulley f_{19}, thence forwards again to the upper barrel of the ratchet arrangement f_{20}, to which the other end is attached. The guide pulley f_{18} is supported from the under part of the carriage. The other band f_{21} is attached at one end to the small end of the other section of the scroll, passes over and around the scroll for a few turns, thence down and backwards around a guide pulley f_{22}, down around a guide pulley f_{23}, and then forwards to the lower barrel of the ratchet arrangement to which the other end is attached. The ratchet arrangement for tightening the bands is attached to the front of the carriage and consists of a bracket carrying the two barrels to which the bands are attached, two ratchet gears, and two pawls. When the carriage runs out, the band f_{16} winds up on the scroll and the band f_{21} unwinds, and vice versa.

28. During the inward run the carriage is driven from the scroll shaft g, Fig. 13, which carries, in addition to g_1, the scrolls g_2, g_3, g_5, of which g_2, g_3 are the **drawing-in scrolls.** Attached at one end to the scroll g_2 is the **drawing-in band** g_6, which passes around the scroll for a few turns, then forwards and around the curved arm of g_7, thence backwards and around the scroll g_4, to which the other end of the band is attached. The scrolls on the scroll shaft gradually increase in diameter until they have attained the required size, when they gradually decrease. This allows the carriage to start in slowly, gradually increase in speed until about the middle of the inward run, and then gradually decrease in speed as it nears the rolls, thus preventing the carriage from banging in and avoiding straining, throwing the carriage out of true, breaking the ends, kinking the ends, etc.

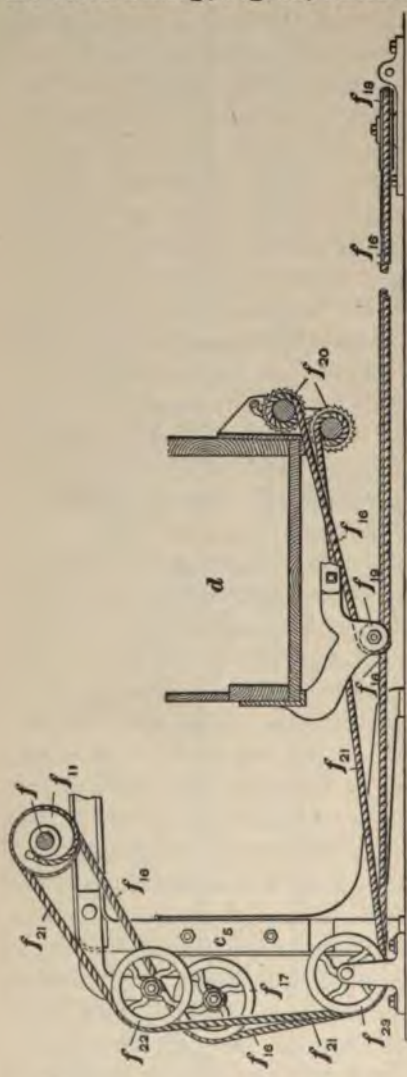


FIG. 15

29. The scroll g_5, Fig. 13, is known as the **checking scroll** and is connected to the carriage by a band g_8 called

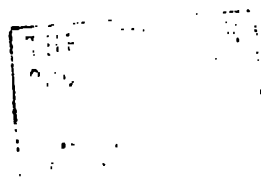
the checking band. This scroll is similar in construction to the other scrolls on the scroll shaft, but is located a little differently on the shaft, in that it is turned farther around. The band g_8 is attached at one end to the inner end of the checking scroll, that is, the end nearest the drawing-in scroll g_4. It passes over and around the scroll, then forwards to the front of the machine, where it passes around a guide pulley g_9, and then backwards to the front of the carriage, the other end being attached to the carriage square d_{23}. The checking band serves to steady the carriage during its inward run and prevents it from overrunning and banging in. When the carriage is at the beam the checking scroll is almost empty, and when the carriage is out its full stretch, the scroll is full. The guide pulley g_9 can be adjusted by a hand wheel at the front so as to give the proper tension to the checking band.

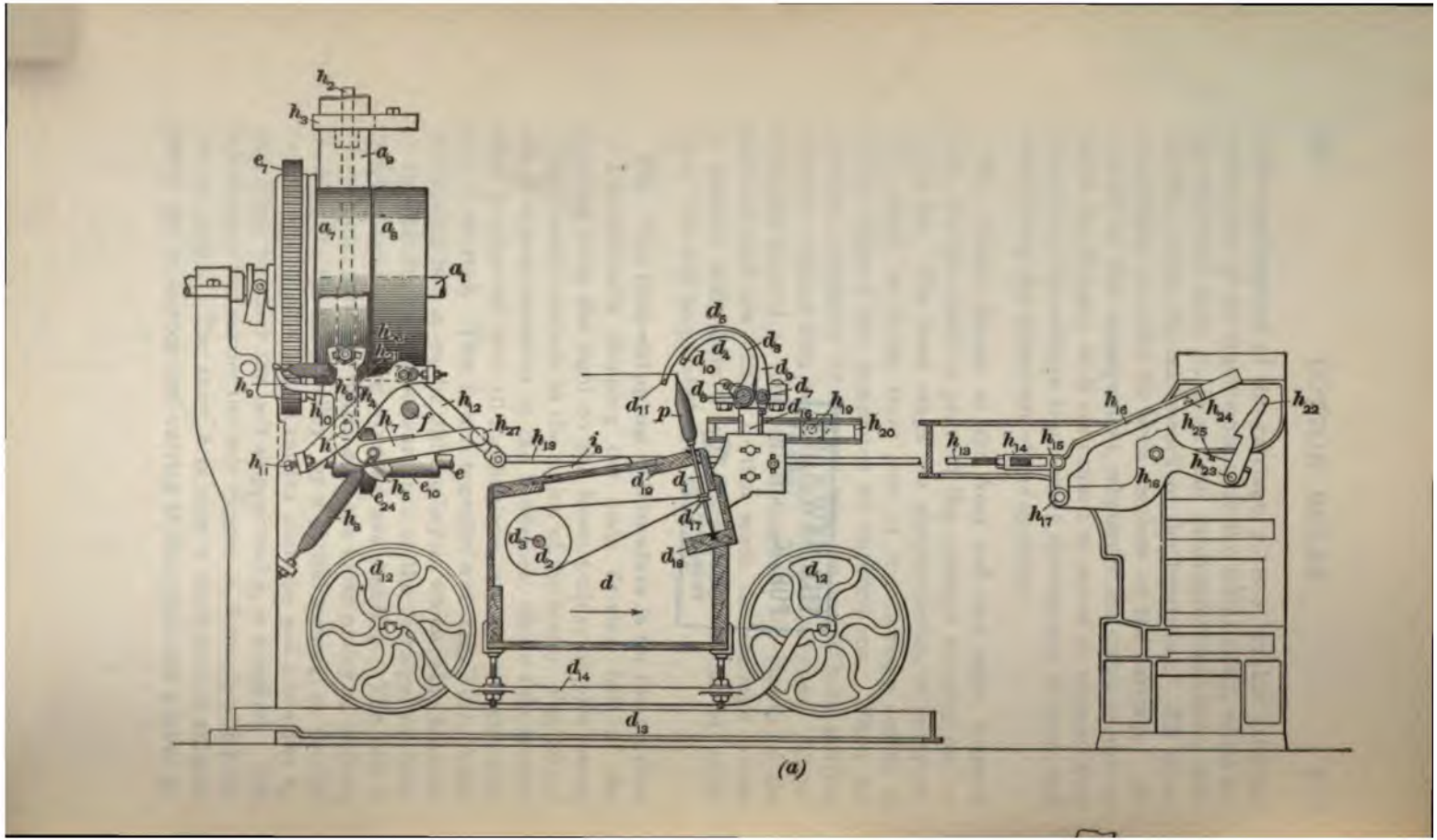
30. The **squaring bands** are for the purpose of keeping the carriage in proper line, so that the spindles will be equidistant from the rolls, and to prevent the carriage from being strained or thrown out of true. It is necessary to have the spindles equidistant from the rolls, so that the yarn will not be strained and broken, and to allow it to be wound on the spindles in proper and regular form. Both sections of the carriage are banded alike, the band g_{10}, Fig. 13, being attached at one end to the barrel of a ratchet gear g_{11} that is supported by a bracket attached to the base of the framework at the front of the headstock. The band passes backwards around the pulley g_{12}, thence diagonally across the under part of the carriage, around the pulley g_{13}, and backwards to the stud g_{14}, to which the other end of the band is attached. The stud is supported near the floor by the end framework of the mule. The other band g_{15} is attached at one end to a ratchet arrangement g_{16} carried by the front part of the end framework. The band passes backwards around the pulley g_{17}, thence diagonally across the under side of the carriage, to and around the pulley g_{18}, and backwards to g_{19}, to which the other end of the band is attached. For the

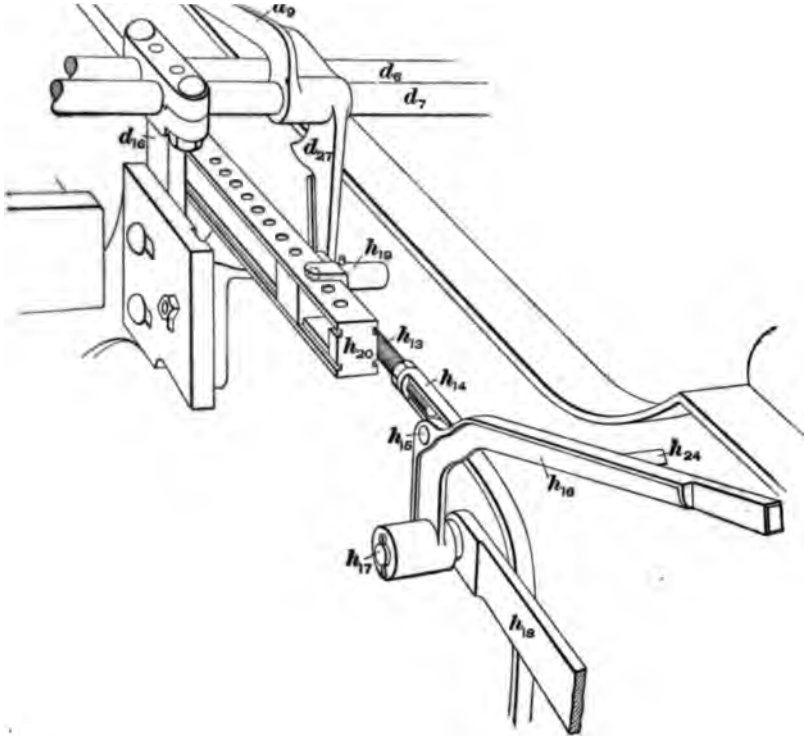
right-hand section of the carriage, g_{11}, is a bracket attached to the base of the framework near the scroll shaft, while for the left-hand side, g_{11}, is an arm projecting outwards, near the floor, from the framework of the headstock. All other connections are alike for both sections of the carriage. As a result of this arrangement, whenever the carriage moves out or in, all parts of it are caused to move in unison, thus preventing the carriage from being thrown out of true, and maintaining the alinement of the spindles.

31. Stops, known as the *front* and *back stops*, respectively, are provided to prevent the carriage running out or in too far. The front stops are simply checks, or bumpers, with which the lower front part of the carriage comes in contact when it has completed its outward run. When the carriage completes its inward run, the lower back portion comes in contact with stops similar to the front ones. These stops are located at intervals throughout the length of the carriage, and are alined so that when the carriage comes in contact with them it will not be thrown out of alinement, but will be parallel with the rolls.

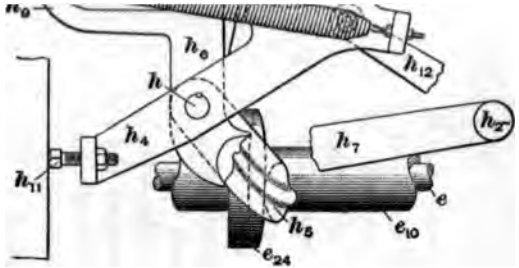
32. The **belt-shipping mechanism** is for the purpose of automatically shipping the main driving belt of the machine from the tight to the loose pulley, or vice versa, during certain periods in the action of the mule. Fig. 16 (*a*) is a sectional elevation at the headstock, where this mechanism is situated, with all mechanisms, etc. not directly connected omitted. This figure, together with Fig. 7 (*a*), shows the driving belt a_6 on the tight pulley a_7, which is the position of the belt during the outward run of the carriage, or technically speaking, during *drawing and twisting*. The belt is moved from the tight pulley a_7 to the loose pulley a_8, or from the loose to the tight pulley, by a partial turning, or oscillation, of the shaft h, which carries near one end a bracket h_1, Fig. 7 (*a*), to which the belt-shipper rod h_2 is attached. The belt-shipper rod carries the belt shipper h_3 through which the belt a_6 passes. The shaft h is only a short one; it extends across the headstock and carries at the other end a lever h_4,



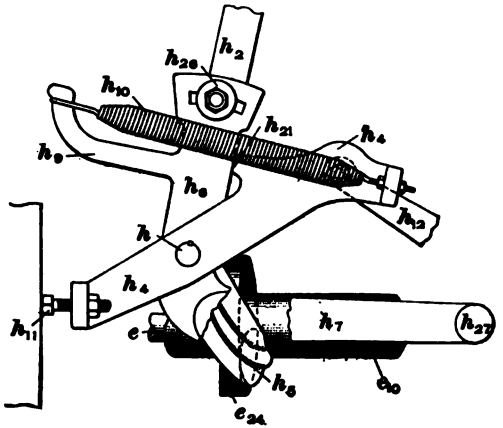

(a)


d_9
d_6
d_7
d_{16}
d_{27}
h_{19}
h_{13}
h_{20}
h_{14}
h_{15}
h_{24}
h_{16}
h_{17}
h_{18}

(b)


h_9
h_6
h_{12}
h
h_4
h_7
h_{27}
h_{11}
e
h_5
e_{10}
e_{24}

(c)


h_2
h_{26}
h_{10}
h_{21}
h_4
h_9
h_6
h_{12}
h
h_4
h_{11}
e
h_7
h_{27}
h_5
e_{10}
e_{24}

(d)

FIG. 16



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ASTOR, LENOX AND
TILDEN FOUNDATIONS

Fig. 16 (*a*), that is keyed to the shaft. The levers h_5, h_6 are fastened together, but are free to swing on the shaft h as a center. The piece h_7 is only an extension arm of the lever h_6. The lever h_6 is held against the face of the cam e_{24} by means of the spring h_8, which is attached at one end to the rear end of the arm h_7 and at the other end to a projection on the framework. Consequently, when the cam revolves, it causes the lever h_6 to swing on the shaft h as a center; and for every revolution of the cam, the lower end of the lever is forced toward the front of the machine and then allowed to recede because of the oblique face of the cam. This movement of the lever h_6 causes the upper end of the lever h_4 to move in the opposite direction; that is, when the lower end of h_6 is in its extreme forward position, the upper end of the lever h_4 is in its extreme backward position.

The lever h_4 has a horizontal arm h_9 extending backwards, to which one end of a spring h_{10} is attached; the other end of the spring is attached to the upper end of the lever h_4. The lower end of this lever carries an adjusting screw h_{11}, the head of which comes in contact with the framework when moved to the rear. This adjusting screw governs the throw of the shaft h so that the belt will occupy its proper position on the loose pulley. A short arm h_{12} connects the upper end of the lever h_4 with the rear end of a rod h_{13} that extends along the outside of the framework of the headstock to a position near the front. The forward end of the rod is attached to the inclined lever h_{15} at h_{16} through a connecting link h_{14}.

The inclined lever h_{15} is pivoted at h_{17} to an arm of a casting h_{18} attached to the framework of the headstock. Depressing this inclined lever draws the rod h_{13} forwards, consequently lowering the upper end of the lever h_4 and raising the lower end until the head of the adjusting screw h_{11} comes in contact with the framework. Lowering the upper end of the lever h_4 causes the shaft h to turn in such a direction that the belt shipper is moved toward the front of the machine, consequently shipping the belt from the tight pulley to the loose one. The inclined lever h_{15} is depressed,

as the carriage nears the end of its outward run, by a stud h_{11} carried by a bracket, or slide, h_{12}, supported by the carriage. This stud comes in contact with the upper side of the inclined lever and gradually depresses it, thus shipping the belt from the tight to the loose pulley. The stud can be moved along the slide h_{12}, and thus be set so that it will be in a position where it can depress the inclined lever at the proper time for shipping the belt a_9.

33. Fig. 16 (*b*) is a perspective view of the front portion of the belt-shipping mechanism. The upper portion of the bracket h_{12} contains a number of holes, into which fits a pin carried by the stud h_{11}. The holes are for adjustment and to allow the stud to occupy different positions. In receding from the rolls, the carriage acquires considerable momentum before it reaches the end of its outward run, and it is advisable to reduce this, as well as the speed of the spindles, as much as possible, so that backing off can take place almost instantly, and also to prevent straining the carriage and other parts. In order that this momentum may be reduced as much as possible, the belt-shipping mechanism under consideration has been adopted so that the driving belt can be moved from the tight to the loose pulley a little before the carriage has completed its outward run, allowing its momentum to complete this motion. The belt should remain on the driving pulley for a greater length of time when running at a low speed and when the mule runs hard, than when running at a high speed and when the mule runs easily. The adjustable-stud arrangement facilitates the regulation of the time of shipping the belt to the loose pulley, as it depresses the inclined lever sooner or later, as required.

Fig. 16 (*c*) shows the positions of the rear parts of the belt-shipping mechanism when the carriage has completed its outward run and the sleeve e_{10} is about to turn, while Fig. 16 (*d*) shows the same parts in their respective positions after the sleeve has turned. When the carriage is running out, the upper portion of the lever h_8 is in contact

with the projection h_{21}, which is a part of the lever h_4. These two levers are thrown out of contact when the inclined lever h_{18}, Fig. 16 (*a*) and (*b*), is depressed by the stud carried by the carriage, but they come in contact again when the sleeve e_{10} turns at the completion of the outward run of the carriage. The carriage having completed its inward run, the sleeve turns again, moving the upper end of the lever h_8 backwards, which draws with it the upper end of the lever h_4, causing the shaft h to turn and thus ship the belt from the loose to the tight pulley for the outward run of the carriage.

The objects of having this mechanism constructed in this manner, that is, motion imparted to h_4 through the lever h_8 and spring h_{10}, are to provide a safety device to prevent the backing-off cone friction being thrown in before the required time, as will be explained later; also, to allow the belt to be shipped from the tight to the loose pulley before the carriage has completed its outward run, without interfering with the operation of the mule.

34. A simple locking device is applied, whereby the inclined lever h_{18} can be depressed and held in this position, causing all parts of the machine to stop as the belt is shipped to the loose pulley. The casting h_{19}, Fig. 16 (*a*), supports a catch h_{22} pivoted at h_{23}. In the figure the catch is shown thrown forwards out of the way, but the inclined lever can be depressed and the catch moved backwards, so that the notch will pass over the projecting lug h_{24} of the inclined lever h_{18} and, consequently, hold down the lever until the catch is moved forwards out of the way. The locking of the inclined lever can be performed any time by hand, or it can be performed automatically at the end of the outward run of the carriage, provided that the catch has been moved backwards previously so that it is supported by the lug h_{24} on the casting h_{19}.

DETAILS OF OPERATION

DRAWING AND TWISTING

35. Drawing and twisting is the first period in the operation of the mule and is for the purpose of drawing the roving to the correct size for the counts of yarn to be made, and for inserting the required amount of twist to give the yarn sufficient strength for the purpose for which it is intended. The carriage is in near the roll beam, and the spindles occupy position (*a*), Fig. 3. The belt is on the tight pulley, and the parts c_{29}, c_{30}, of the front-roll clutch, Fig. 7 (*a*), are thrown into contact by the cam e_{33}. The hub of c_{30} is grooved to receive a fork carried by a lever c_{31} that is pivoted at c_{32}. A projection on the lever c_{31} is held in contact with the face of the cam e_{33} by a spring c_{33}. When the lever is resting on the portion of the face of the cam that is nearest to its center, the clutch is locked, but when the highest portion of the cam is in contact with the lever, its parts are out of contact.

The parts of the clutch being in contact, the rolls commence to revolve, drawing the roving from the bobbins in the creel, and inserting the required amount of draft to reduce it to the desired size for the counts of yarn to be spun. As the rolls start to deliver, the carriage commences to recede, and the spindles to revolve, in order that the attenuated roving may be twisted as it is delivered. The receding of the carriage while the stock is being delivered and spun into yarn, keeps the ends tight until the carriage has completed its outward run, when the rolls stop delivering and the spindles stop twisting the yarn. Fig. 7 (*a*) shows the cams, together with the adjacent parts, in the position that they occupy just as drawing and twisting commences.

36. During this operation, the carriage is driven direct from the back shaft *f*, Fig. 17, which is caused to revolve by the parts f_6, f_7 of the toothed clutch being placed in contact with each other by the connection of f_7 with the cam e_{35}. As

the cam is situated between the jaws of the lever f_{24}, which is pivoted at f_{23}, it causes the lever to swing on its pivot when it revolves. A projection f_{25} of the lever f_{27} is held in contact with the lever f_{24} by the spring f_{29}, and consequently when the lever f_{24} is caused to turn on its pivot by the cam e_{23}, it causes the lever f_{27} to swing on its pivot f_{28}. The lever f_{27} is really in two sections, in order to facilitate the adjustment of the clutch parts f_6, f_7. When the lever f_{27} turns on its pivot, it causes the upward projecting arms, carrying the

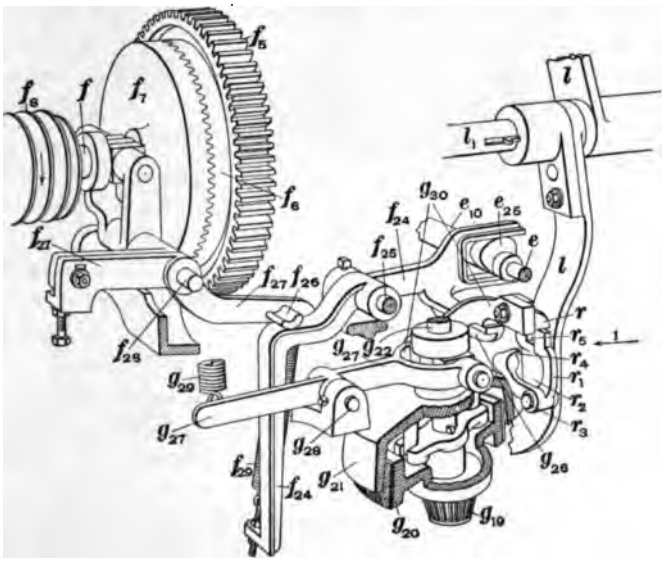


FIG. 17

forks that fit into the groove in the hub of the part f_7, to swing, and thus throw the part f_7 into or out of contact with the other part f_6, according to the direction of their motion.

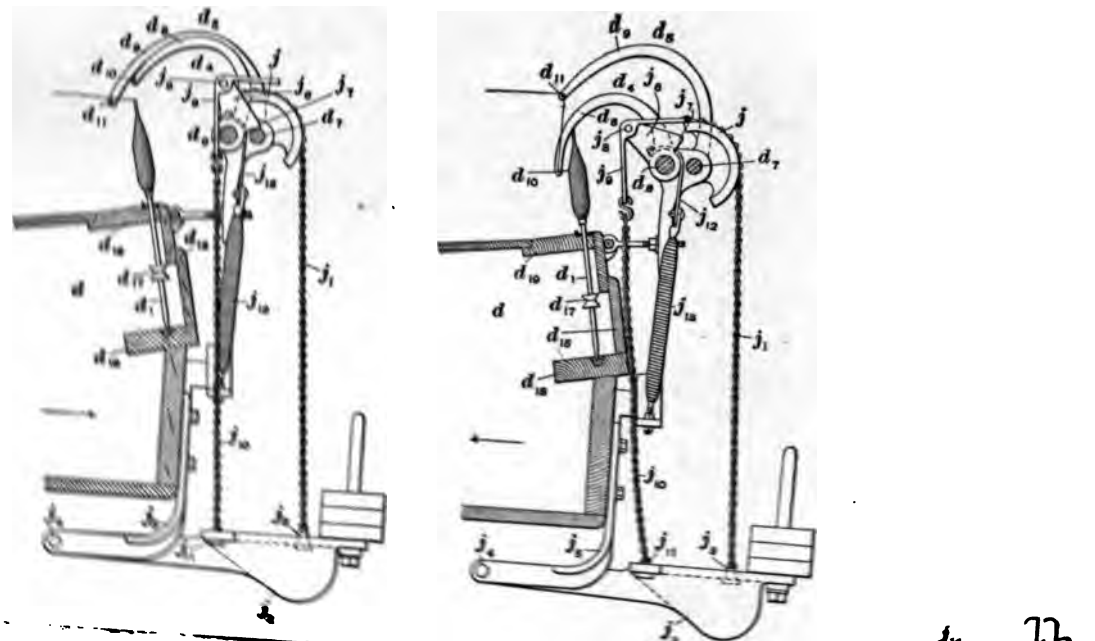
When the forked end of the lever f_{24} is raised, it causes the opposite end to be depressed and, since the projection f_{25} is held in contact with f_{24}, the lever f_{27} turns on its pivot and the upper portion of the upright arms moves to the right, Fig. 17, thus causing the two parts of the clutch to lock. When the forked end of the lever f_{24} is lowered, the clutch is disconnected.

The spindles are driven direct from the rim shaft, which is caused to revolve by the belt being on the tight pulley a_7, Fig. 12. The rim pulley a_{10} operates the rim band a_{11}, which, by means of the necessary guide pulleys, imparts motion to the pulley d_{21} on the cylinder shaft d_5; the cylinder carries the bands that pass around the whorls of the spindles.

37. The fallers, throughout the entire drawing-and-twisting period, occupy the position shown in Figs. 3 and 18 (*a*), with the winding-faller wire above the yarn and the counter-faller wire below, in order that they may be out of contact with the yarn and thus not interfere with the twisting operation.

The counter-faller shaft d_7, Fig. 18 (*a*), carries a segment bracket j, to which is attached one end of a chain j_1, while the opposite end of the chain is attached to the weighted lever j_3 at j_5; this lever is pivoted at j_4 to a bracket j_2 attached to the carriage. The amount of weight on the lever can be adjusted by changing the number of weights, or disks, on it. The segment bracket is fastened to the counter-faller shaft d_7 so that one cannot move without the other. Securely fastened to the winding-faller shaft d_6 is a bracket j_6. A projection j_7 of this bracket extends out sufficiently to rest on the upper surface of the counter-faller shaft, as shown, during drawing and twisting; thus, the winding faller d_4 assumes the same position each time these operations take place.

Pivoted to the upper portion of the bracket j_6 at j_8 is an elbow lever j_9, to the lower end of which is attached a chain j_{10}. The lower end of this chain is connected at j_{11} to the lever j_3. Attached to the hub of the bracket j_6 is a strap j_{12} that is connected to the upper end of a spring j_{13}, the lower end of which is connected to a casting attached to the front of the carriage. The spring, being under tension and connected to the winding-faller shaft as described, tends to turn the faller shaft so that the winding faller will assume a higher position. It is prevented from so doing, however,



(a) (b)

Fig. 11

by the projection j_7 coming in contact with the counter-faller shaft.

During this period in the operation of the mule, the outer end of the lever j_3 is supported by the chain j_{13}, the tension on the chain j_1 being merely that caused by the weight of the counter faller, which is thus kept during this period in its proper position below the yarn by its own weight. Just as the carriage completes its outward run, the projection on the under side of the lever j_3 comes in contact with the incline j_{14}, thus raising the lever and removing the tension on the chain j_1, and consequently on the counter faller, during backing off. The lever j_3 being supported by the incline j_{14}, when the fallers change and assume their positions for winding, the counter faller will rise with less force and hence will be less liable to break the yarn. As the carriage starts on its inward run, however, the lever j_3 slides down the incline j_{14} until it is supported by the chain j_1, whereupon the full force of the upward tendency of the counter faller will be exerted on the yarn and thus kinks in the yarn prevented and a proper tension for winding insured. There are a number of these brackets, chains, levers, springs, etc. throughout the length of the carriage, but there are only one or two inclines similar to j_{14} for each section of the carriage. These inclines, together with their respective faller connections, are termed **yarn-casing motions.**

38. The belt-shipping mechanism operates on the main driving belt of the mule just before the carriage completes its outward run. The stud h_{15}, Fig. 16 (a), comes in contact with the inclined lever h_{14} and depresses it, so that the belt a_1 is shipped from the tight pulley a_7 to the loose pulley a_8, in order to reduce the momentum of the carriage, and thereby prevent it from banging out, and also to allow backing off, which is the next period in the action of the mule, to take place without delay.

39. At the end of the outward run of the carriage it is advisable to lock the carriage by a **holding-out, or locking, catch,** so that it may remain in this position until backing

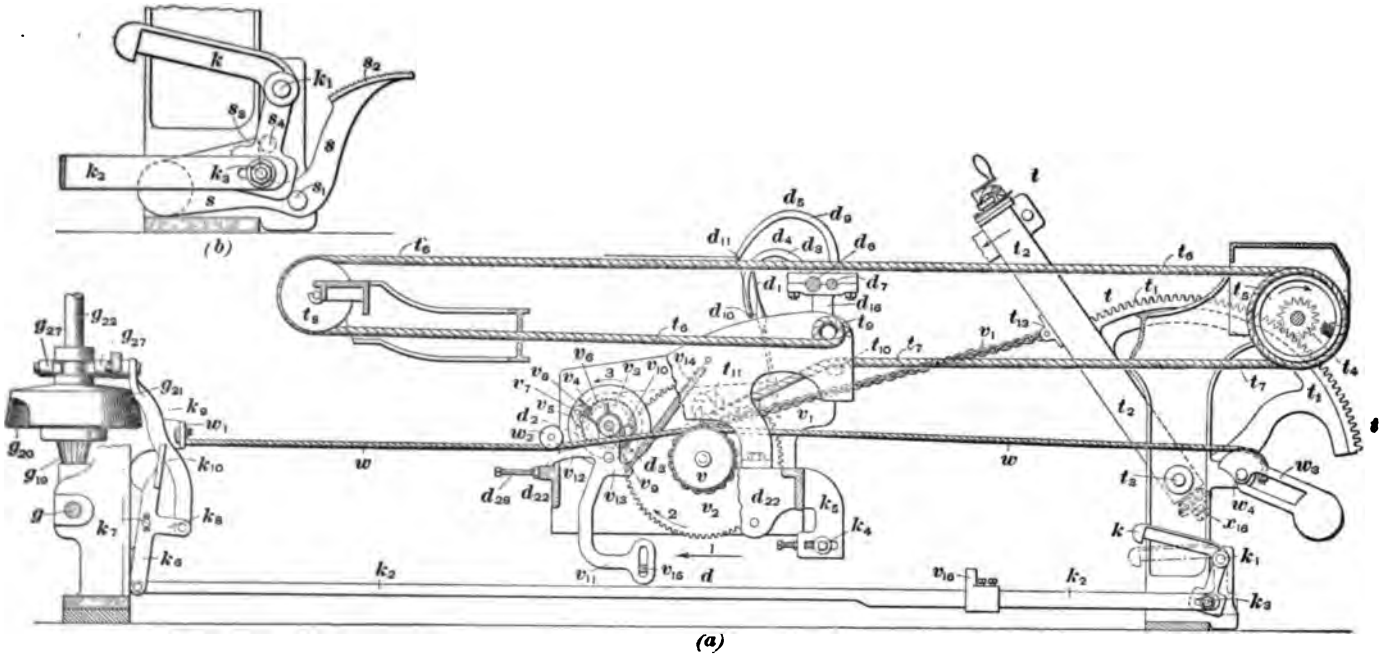


FIG. 19

off is completed and winding just about to commence. The holding-out catch k, Fig. 19 (a) and (b), is situated at the front of the headstock and is pivoted at k_1. Its lower end is attached to the rod k_2 at k_3, and is caused to oscillate on its pivot when the rod k_2 is moved toward either the front or the back of the headstock. The outer end of the catch terminates in a hook, so that when it passes over the stud k_4, it will prevent the carriage running in until the catch is released, as the stud is supported by a bracket k_5 that is attached to the front of the carriage square. When the carriage is running out, the catch occupies the position shown in dot-and-dash lines in Fig. 19 (a), so that its hooked portion will drop over the stud k_4 when the carriage has completed its outward run, and thus prevent it from starting in before the proper time.

40. The amount of time consumed during drawing and twisting is about $9\frac{1}{2}$ seconds for the 62-inch-stretch mule under consideration.

BACKING OFF

41. The second period in the action of the mule is technically known as **backing off.** During this period certain parts must be stopped and then reversed, in order that the open coils of yarn between the end of the spindle and the nose of the cop may be removed, that the fallers may assume their proper positions for winding, and that the yarn may be properly wound on the spindle, so that the yarn will unwind rapidly and easily from the cop at the next process.

42. Engaging of Backing-Off Friction.—In order that the open spirals or coils of yarn, shown in Fig. 4 on the spindle blade, may be removed, the spindle must revolve for a few turns in the opposite direction to that of twisting. This reversal of the direction of rotation of the spindles is accomplished by the backing-off cone friction, which is composed of a large gear e_7, Fig. 20, containing a hollow conical shell, into which fits a cone with a leather-covered face that is a part of the tight pulley a_7. The gear e_7, which is loose

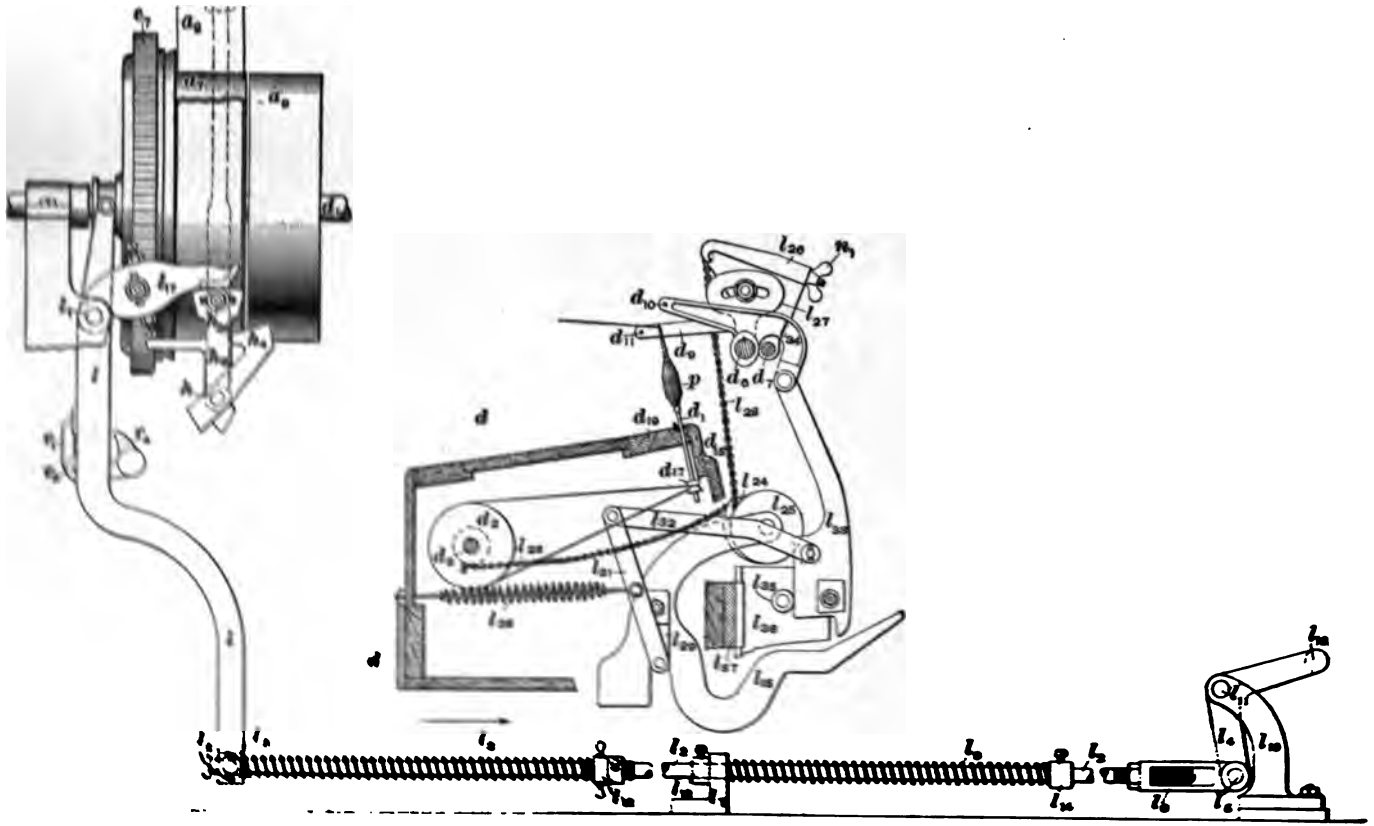


Fig. 39

on the rim shaft, revolves in the opposite direction to that of the tight pulley a_7 during drawing and twisting, being driven from the backing-off-friction driving shaft, or, as it is frequently called, the *taking-in shaft*.

Since the belt a_8 has been shipped to the loose pulley a_6 (just before backing off was to take place) the gear e_7, when the backing-off cone friction is thrown in, will cause the tight pulley a_7, together with the rim shaft and the rim pulley, to revolve in the opposite direction to that in which they revolved during drawing and twisting. With the direction of motion of the rim pulley thus reversed, the spindles will also revolve in the opposite direction, thus unwinding the open spirals of yarn from the blades of the spindles.

The cone friction is thrown in by the backing-off lever l, Figs. 17 and 20, which is mounted on a shaft l_1 that is free to oscillate in bearings formed in the framework of the head-stock. The lever is really in two sections, as shown in Fig. 17; the upper end operates in the groove in the hub of the gear e_7, and as the gear is free to slide on the rim shaft, the friction shell is thrown in when the upper end of the lever is moved forwards, and thrown out when it is moved backwards. The lower end of the backing-off lever is connected to the backing-off rod l_2, Fig. 20, by a swivel connection at l_3 through which the rod can slide. The backing-off rod passes to the front of the machine, where it is connected to the bell-crank lever l_4 at l_5 by a connecting link l_6. About midway, the rod is supported by a bracket l_7 and carries on either side of the bracket the springs l_8, l_9. The bell-crank lever is supported by a bracket l_{10} and is pivoted at l_{11}. The rear end of the spring l_8 presses against the backing-off lever l, while the front end is in contact with the rear side of the threaded checking collars l_{12}. The collar l_{13} is setscrewed to the backing-off rod, and comes in contact with the bracket l_7, preventing the rod from moving too far as the spring l_8 tends to force it forwards. The rear end of the spring l_9 bears against the bracket l_7, while the front end is in contact with the collar l_{14} setscrewed to the rod.

The carriage carries a fish-jaw lever l_{18}, the inclined face of which comes in contact with the projection l_{19} on the outer end of the bell-crank lever, depressing the lever just as the carriage completes its outward run. This causes the backing-off rod to move backwards, thus compressing both springs l_3, l_4. The backward movement of the backing-off rod tends to cause the backing-off lever to swing and oscillate the shaft l_1, but it is prevented from so doing until the

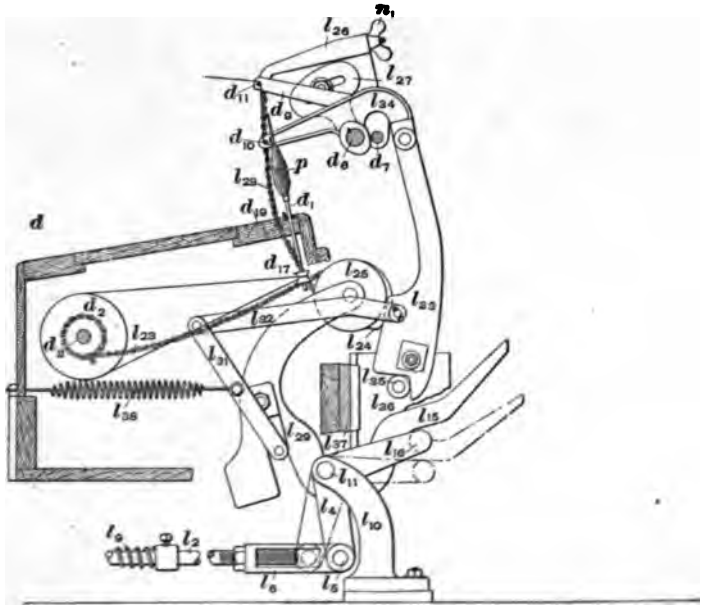


FIG. 21

required time, which is after the belt is on the loose pulley and the carriage locked at the completion of the outward run, by the safety, or locking, device.

As the backing-off lever l and the safety, or locking, arm l_{17} are fastened together, the backing-off lever cannot swing until allowed to do so by the locking arm. The backing-off lever is locked by the front portion of the locking arm resting on a bowl h_{10} carried by the upper portion of the lever h_9. As this bowl is removed from under the locking arm by the

upper end of the lever h_4, moving forwards when the carriage has completed its outward run, it will allow the upper end of the backing-off lever to swing forwards and throw in the friction, as the lower end is forced backwards by the spring l_4. The position of the bell-crank lever l_4 and the fish-jaw lever l_{11} during backing off, when the friction is in, is shown in dot-and-dash lines in Fig. 21.

43. The position of the fallers must be changed from that assumed during drawing and twisting to that required for winding, which is just the reverse; that is, the counter faller is above the ends of the spindles, and the winding faller below. The yarn passes over the counter-faller wire, downwards and under the winding-faller wire, and thence to the cop on which it is wound.

Keyed to the cylinder shaft d_3, Fig. 22, is a ratchet gear l_{14}, in close proximity to which is a disk l_{13} compounded with a barrel l_{12}, both being loose on the cylinder shaft. The disk carries a pawl l_{15} that operates on the ratchet gear, which has a grooved hub around which fits a friction spring l_{16}. One end of the spring is bent fork-shaped, the two tines projecting sufficiently to come in contact with and enclose a stud in the arm of the pawl; one of the tines is longer and extends beyond the other one and rests on the outer portion of the stud on which the pawl is mounted.

When the cylinder shaft is revolving in the direction indicated by arrow *3*, Fig. 19 (*a*), which is the case during spinning and winding, the friction on the spring l_{16}, Fig. 22, will then tend to turn it, but is prevented from so doing by one end being in contact with the stud on which the pawl l_{15} is mounted; this tendency of the spring keeps the pawl out of contact with the ratchet gear. When the cylinder shaft turns in the opposite direction, which is the case during backing off, the tendency of the spring to turn is also reversed and, consequently, the pawl l_{15} comes in contact with the ratchet gear l_{14}, thus causing the disk l_{13} and drum l_{12} to revolve.

One end of the chain l_{17} is attached to the drum, and as

the drum revolves the chain is therefore wound on its surface. As the other end of the chain is attached to the scroll l_{24}, winding the chain on the drum causes the scroll to revolve, the chain being unwound from the scroll. The scroll l_{24} is compounded with another scroll l_{25}, both being

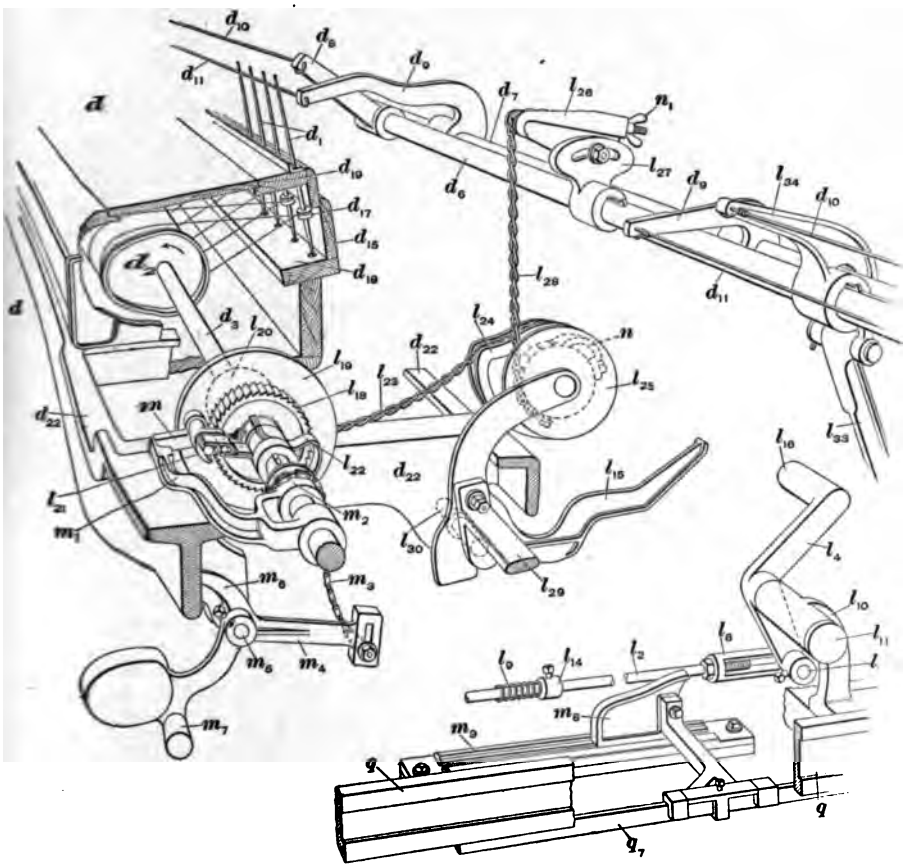


FIG. 22

mounted on a stud carried by the upper arm of the fish-jaw lever l_{14}. The scroll l_{25} is connected by a chain l_{28} to an arm l_{26}, which is frequently known as the *backing-off*, or *faller*, *arm*, and is attached by a bracket l_{27} to the winding-faller

shaft. When the chain l_{28} is unwound from the scroll l_{24}, it causes the chain l_{29} to wind on the scroll l_{25}, and thus turn the winding-faller shaft so as to lower the winding faller to the proper position for winding, which position is controlled by the position of the builder rail, as will be explained.

As the open spirals of yarn unwind from the spindle blades and the winding faller lowers, the counter faller rises, to keep the yarn under tension. The raising of the counter faller is brought about by the pull exerted by the weighted levers similar to j_2, Fig. 18, acting through the chains similar to j_1, because the winding faller turns and slackens the chains j_{10}, thus allowing the levers to be supported by the chains j_1. All levers operate except those that form part of the yarn-easing motions.

44. Disengaging of Backing-Off Friction.—The bell-crank lever l_4, Fig. 22, is released when the winding faller assumes its proper position for winding, because the fish-jaw lever l_{18} swings on its center l_{30}, so as to raise the arm that comes in contact with the projection l_{16} of the bell-crank lever. The fish-jaw lever is attached to a cradle arm l_{26}, one end of which is supported by the stud l_{36} projecting into a bearing in one of the cross-beams of the carriage square d_{22}, while the opposite end is supported in a similar manner; the stud is a part of the cradle arm. As the spring l_9, Figs. 20 and 22, is compressed while the backing-off friction is in, it tends to force the backing-off rod outwards, but is prevented from so doing as long as the fish-jaw lever keeps the outer end of the bell-crank lever depressed. When the fish-jaw lever is raised, the pressure on the outer end of the bell-crank lever is released and the backing-off rod is forced forwards by the spring l_9. The rod, in moving forwards, throws out the backing-off friction.

45. Locking the Winding Faller.—Near the other end of the cradle arm, and forming a part of it, is an upright arm l_{31}, Figs. 20 and 21, attached to the upper end of which is an arm l_{32} that is connected at its opposite end to an arm l_{33} known as the *boot leg;* the upper end of this arm is

connected to the front end of an arm l_{34}, which is keyed to the winding-faller shaft and extends backwards sufficiently to form one of the end supports for the winding-faller wire. As the winding-faller shaft turns, on account of the chain and scroll connection, it causes the rear end of the arm l_{34} to be depressed and the front end raised, thus drawing up the boot leg l_{33} sufficiently to allow the lower end to be drawn over the bowl l_{35}. The bowl is carried by a casting l_{36} that moves up and down in a slide l_{37}, attached to the front of the carriage. The lower portion is formed so as to carry a bowl that rests on the builder rail, which will be described later. The tendency of the spring l_{38} is to keep the face of the boot leg pressed against the bowl l_{35}, as shown in Fig. 20, and to draw the lower end of the boot leg over the bowl when raised high enough, as shown in Fig. 21. This action is called **locking the faller,** and it places the winding faller in position to be controlled by the builder rail during winding, which is the next period in the action of the mule. Fig. 22 is an enlarged view showing the position of the winding faller d_7 when locked for winding, and also the position of the counter faller d_8 at the same period.

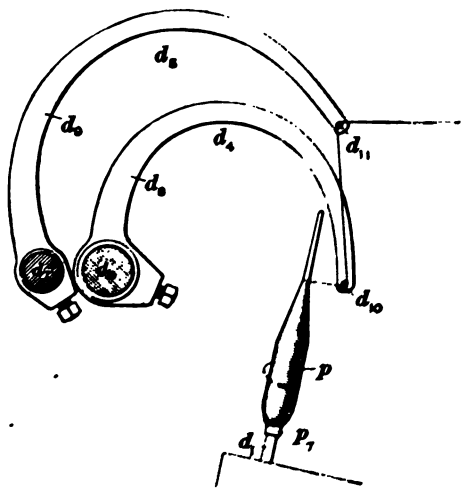


Fig. 22

As the boot leg bears against the bowl l_{35}, Fig. 20, it prevents the fish-jaw lever rising or turning on its center until the boot leg has been raised sufficiently high to allow the lower end to slip over the bowl. When this takes place the spring l_{38} will cause the cradle arm to turn so as to raise

the front portion of the fish-jaw lever l_{15} and thereby release the backing-off rod and friction. The oscillation of the fish jaw slackens the chains l_{20}, l_{23}, and when the direction of rotation of the cylinder shaft is changed from that of backing off, the pawl l_{21} is thrown out of contact with the ratchet gear.

46. As the cop increases in length, the number of open spirals of yarn on the blade of the spindle between the nose of the cop and the end of the spindle decreases proportionately, thus giving a shorter length of yarn to be removed during backing off. This length is also reduced on account of the taper of the spindle. As the number of open spirals of yarn on the spindle blade gradually decreases, the required number of revolutions of the spindle to remove these open spirals will be less and less. The builder mechanism is the direct controlling power for this gradual decrease.

The builder rail lowers gradually at the completion of each outward run of the carriage, and as the casting l_{36}, Figs. 20 and 21, is supported, and its vertical movement controlled, by a bowl resting on the upper surface of the rail, the casting will gradually be lowered with the rail. The lowering of the casting l_{36} carrying the bowl l_{34} at the completion of each outward run of the carriage, allows the faller to lock more quickly each time, as the boot leg does not have to be raised as high as the previous time; consequently, the backing-off friction is thrown out more quickly; that is, the friction is not in for so long a time near the completion of a set of cops as at the beginning.

47. The **backing-off chain-tightening motion** is applied for automatically tightening the backing-off chain l_{19} as the cops increase in size, because there is a smaller amount of yarn on the blade of the spindles, and also because the winding faller does not have so great a descent, or distance to travel. When a set of cops is first started, the amount of yarn wound on the spindle blades between the noses of the cops and the ends of the spindles is considerable, and the spindles should unwind, during backing off,

just a little, before the fallers operate on the yarn, so that the winding faller will not press too heavily on the yarn and strain or break it. As the cop increases in size this is not as necessary, since there is less yarn to be unwound, and the winding faller does not have so great a distance to travel, thereby being less liable to overtake and strain or break the yarn before backing off is completed; consequently, the backing-off chains are tightened so that the winding faller will start downwards a little earlier, until when the cop is almost complete, the faller starts immediately.

Situated between the ratchet gear l_{10}, Fig. 22, and the disk l_{11} is a lever m that swings loosely on the cylinder shaft. The shoulder of the stud that carries the pawl l_{21} rests on this lever, which, in connection with other mechanism, prevents the disk from turning down. This arrangement also serves for another purpose, which will be described presently. The outer end of the lever m rests on the end of a lever m_1, which is also loosely mounted on the cylinder shaft and when in the position shown in Fig. 22 rests on the upper surface of the carriage square d_{33}. A portion of the hub of this lever terminates in a barrel m_2, on which a portion of the chain m_3 is wound. One end of this chain is attached to the barrel, while the other is attached to the front portion of a lever m_4 that is pivoted at m_5. A projection m_6 prevents the rear portion of the lever m_4, which is weighted, from assuming a lower position than that shown in Fig. 22. The rear portion, besides being weighted, carries a projection m_7 that comes in contact with the inclined face of the casting m_8 shortly before the carriage completes its outward run, thus raising the rear portion and lowering the front to which the chain m_3 is attached. Lowering the front portion of the lever m_4 draws the chain downwards and unwinds it from the barrel on which it is wound, thus causing the lever m_1 to turn on the shaft, so that the rear end that rests under the lever m is raised; this raises the lever m and thereby turns the disk l_{11} and, consequently, the barrel l_{30}, so that a portion of the chain l_{33} is wound on the barrel, thus taking up some of the slack. Tightening the chain l_{33},

which of course tightens the chain l_{11} proportionately, allows the winding faller to be drawn down earlier when the backing-off friction is in.

As the cop increases in size, the casting m_8 is moved inwards along its bed m_9, on account of its connection to the builder mechanism; consequently, the projection m_7 is raised higher at each outward run of the carriage, as it comes in contact with a higher portion of the inclined face of the casting. The higher the projection m_7 is raised, the greater the amount of chain wound on the barrel l_{11} before backing off commences. Tightening the chains l_{13}, l_{14} gives a firm nose to the cop, since backing off ceases when the nose of the cop is reached, instead of a little below, as is the case when the chains are slack and the lower portion of the cop is being formed.

48. A hastening motion is sometimes applied, but it is used principally when spinning coarse and medium counts. A curved casting n, Fig. 22, is attached to the surface of the scroll l_{11} by a setscrew and is adjustable, as there are a number of holes in the scroll in which the setscrew may be placed. This casting comes in contact with the chain l_{12} just as backing off is completed, and as the diameter of the scroll is thus increased, more chain is taken up and the downward movement of the winding faller quickened, and consequently the upward movement of the boot leg. Setting the casting so that it comes in contact with the chain l_{12} early, or tightening the chain l_{14} by turning the winged, or lug, nut n_1, makes this motion more *keen;* that is, the downward movement of the winding faller is quickened and the tension on the yarn increased; and vice versa when the opposite adjustments are made.

49. With the winding faller locked, and the backing-off driving mechanism thrown out, the period known as backing off is completed. The length of time necessary for the mule to back off is considerably less than that necessary for drawing and twisting, being about $1\frac{1}{2}$ seconds in the case under consideration.

WINDING

50. Winding is the third period in the cycle of operations of the mule, and is necessary in order that the yarn that has been delivered and twisted may be built up in suitable form on the spindles. When winding commences, the carriage is in its extreme outward position, or at the end of its *stretch*, as it is frequently termed. As the carriage and spindles are in position (*b*), Fig. 3, there is a considerable length of yarn suspended between the spindles and the drawing rolls; therefore, the spindles must revolve and the carriage run inwards to the beam, in order that the yarn thus suspended may be gradually wound on the cops that are being formed on the spindles.

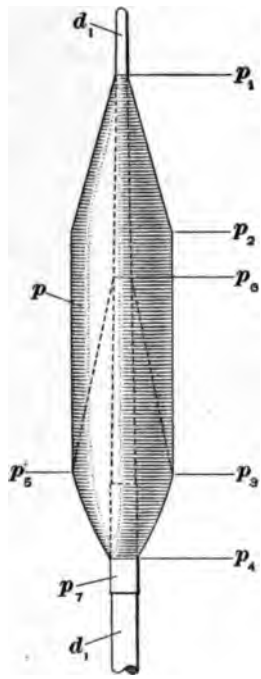


FIG. 24

51. Construction of the Cop. A full cop on a spindle is shown at *p*, Fig. 24. The **nose** p_1 is the minimum diameter, and the **shoulder** p_2 the maximum. The **body** is the general name for the cylindrical portion $p_2 p_3$, while the **bottom** is the portion $p_3 p_4 p_5 p_6 p_7$. The cop is first started on the paper tube p_7, which is placed on the bare spindle; this tube stiffens the bottom by serving as a foundation for the cop. The determination of the **chase** of a cop is a point about which there is considerable difference of opinion, but is generally conceded to be the surface on which the yarn is wound, the length of which is the distance from the nose p_1 to the shoulder p_2. The terms nose, shoulder, and chase are applied to the cop during its formation, as well as at its completion. Correctly speaking, the nose can range all the way up the spindle during the

formation of the cop; for instance, from p_4 to p_1; the shoulder from p_3 p_4 to p_2; and the chase from the nose to the shoulder in each case as p_6 to p_3, or p_6 to p_5, and p_1 to p_3.

52. When winding commences, as it does immediately after backing off, the fallers d_4, d_8 are in the position shown in Fig. 23. Near the spindles, the yarn passes over the counter-faller wire d_{11}, then downwards and partly around the winding-faller wire d_{10}, and thence to the spindle at the nose of the cop. The yarn by passing over the counter-faller wire, is kept under tension during winding by the upward tendency of the wire; by passing under the winding-faller wire, it is guided to the cop and wound on its surface, according to the position of the winding-faller wire.

As the carriage starts on its inward run, only part of the total number of weighted levers j_2, Fig. 18 (*b*), tends to raise the counter faller and keep the yarn under tension. This prevents the yarn being strained during, and at the completion of, backing off. After the carriage has started in, however, the under sides of the weighted levers j_2 that have been resting on the inclines j_{14} are removed from contact with the inclines by the inward movement of the carriage, so that all the weighted levers throughout the entire length of the carriage are free to exert a pull on the chains j_1 so as to tend to raise the counter faller, and thus give the proper tension to the yarn during winding, thus preventing snarling, etc.

53. The Builder Motion.—The formation of the cop is controlled by the **builder motion,** which regulates the length of time that the spindles revolve during backing off, the position of the winding faller at the end of backing off, and its position during the time that the yarn is being wound on the spindles.

The builder proper consists principally of two parts—the cast-iron **rail** and the **shoes.** The main, or long, rail q, Fig. 25, is in one piece, being supported at the front and rear ends by studs q_1, q_2, resting on the upper edges of the front and back shoes q_3, q_4, respectively. A cross-section

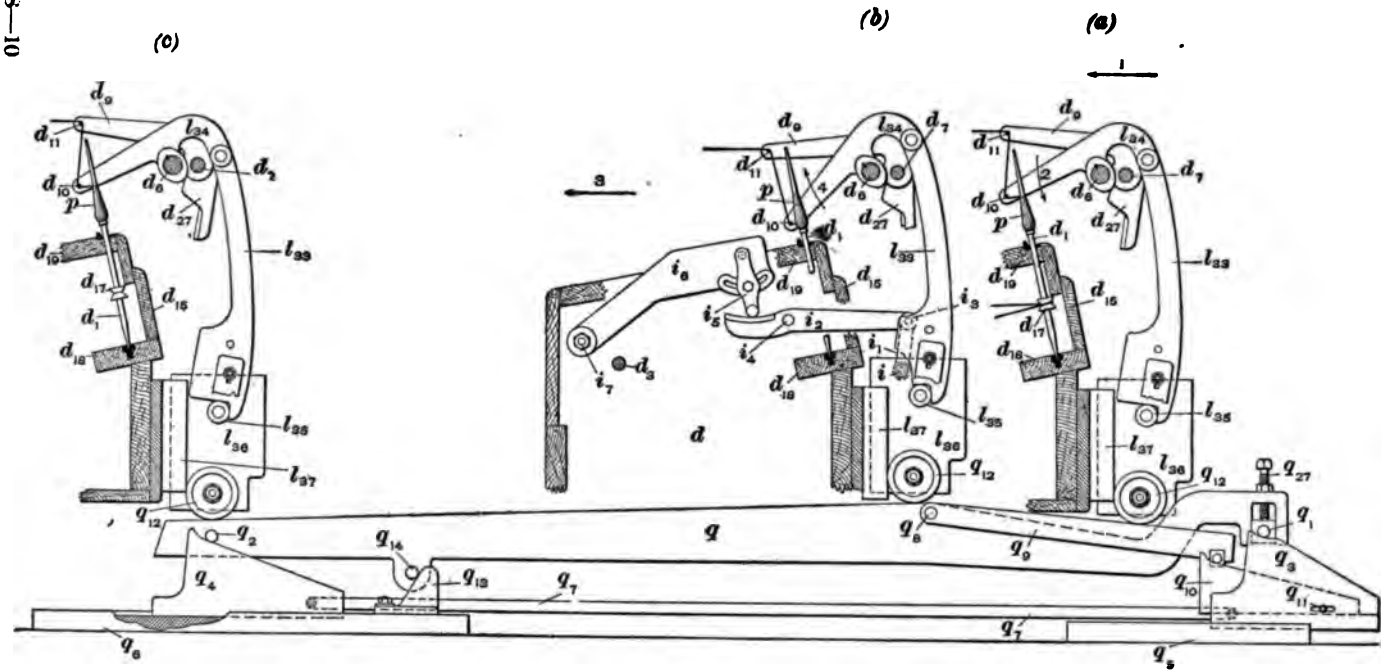


FIG. 25

of the rail q can be seen in Fig. 22, as a portion of it is broken away. The rail is supported with the narrow face, or edge, up, so that it will be stiff and free from deflection, which would be a very serious defect, as the shape of the face, which determines the position of the winding faller,

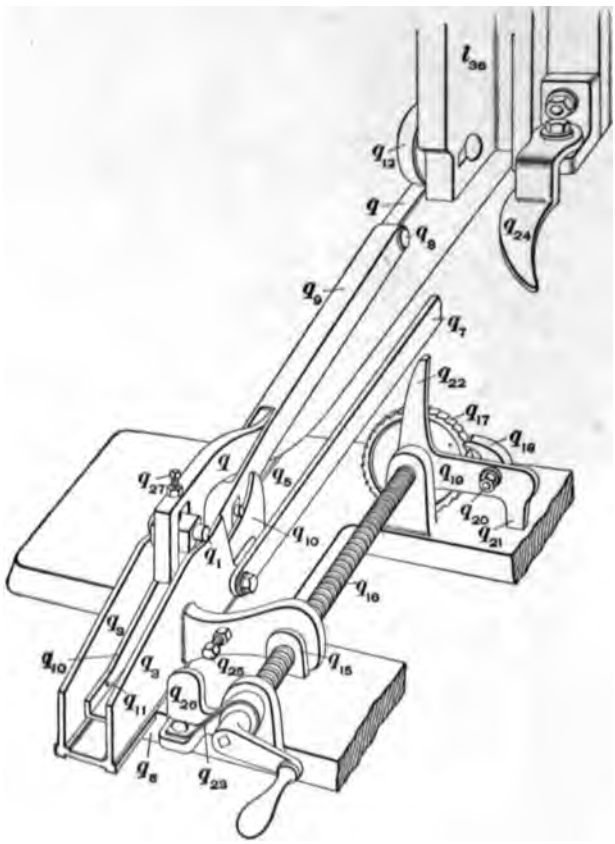


FIG. 26

would be materially affected. The upper surface of the rail is not horizontal, but inclined, with the extreme front end curved as shown.

The shoes q_{21}, q_4 slide in beds q_{22}, q_{23}, respectively, that are attached to the floor; they are joined by a connecting-rod q_{17}.

Each shoe has two sides between which the rail may pass. At each end of the rail is a stud that projects on each side sufficiently to rest on the upper edges of the sides of the shoes, thereby supporting the rail. The shoes are sometimes called *inclines*, or *plates*. The general shape of the front shoe is shown in perspective in Fig. 26; the rear shoe is of similar construction, but it is not shown in this illustration.

Pivoted to the highest part of the rail q at q_9, Figs. 25 and 26, is a supplementary casting, or short rail, q_8, known as the *loose incline*. The loose incline is much shorter than the inclined part of the main rail q, as shown. Its outer end is supported, in a similar manner to the ends of the long rail, by the shoe q_{10}, which is a little narrower than the shoe q_3 so that it can rest inside the latter. These two shoes are fastened together by a binding screw q_{11} passing through a slot in the shoe q_3 into the shoe q_{10}. The slot in the shoe q_3 is for adjustment, so that the relative positions of the two shoes can be changed.

54. As the cops increase in size, the builder rail is lowered, in order that the winding faller may not be depressed as far as previously, to wind the yarn higher up on the spindle. By lowering the rail, the bowl q_{12} that rests on it will also be lowered and with it the casting l_{24}, thus allowing the boot leg and front portion of l_{24} to assume a lower position. This will allow the faller to lock earlier, thus preventing its being depressed to so great an extent as previously. The rail is lowered, as the cop increases in size, by the shoes being moved backwards slightly at the completion of each outward run of the carriage. The mechanism for accomplishing this object operates directly on the front shoe, but the back one is moved also, because it is connected to the front one by the builder-shoe connecting-rod q_7, Figs. 25 and 26. The middle shoe, or the one supporting the outer end of the loose incline q_8, is connected directly to the front shoe; consequently, any motion imparted to the front shoe must necessarily be imparted to the middle one.

The rail is steadied in its downward movement, and i s action made positive, by the bracket, or guide, q_{13}. A stud q carried by the rail rests on the inclined face of the guid e. The tendency of this arrangement is to press the rail bac k- wards, and thus keep the studs supporting the rail in dire ct contact with the inclined surfaces, or upper edges, of th he shoes, so that when the position of the shoes is changed, th he rail will receive motion. The guide also moves the ra ail backwards slightly as it is lowered, on account of the dire c- tion of the incline of its face.

55. The backward movement of the shoes is accon m- plished by the front shoe, which has on one side a projectio on that extends outwards, being so shaped as to fit into a groove in a peculiarly shaped nut q_{18}, Fig. 26, operated by th he builder screw q_{18}. The screw is supported at each end b by upright supports; its rear end carries a ratchet gear q_{17}, tha at is operated by the pawl q_{16}. The pawl is pivoted to th he lever q_{19} at q_{20}, the lever, in turn, being pivoted on th he builder screw between the ratchet gear and the rear sup p- port of the screw. The lever is supported in the positio on shown, when the carriage is running out or in, by a projec c- tion q_{21}. Raising the end of the lever carrying the pawl, b by pressing the upright arm q_{22} over toward the builder rail i causes the pawl to turn the ratchet gear; when the pressure r on the upright arm is released, the lever and pawl assume n their normal positions again. The builder screw, in turning g must overcome the friction or resistance produced by the h pressure of the flat spring q_{23}. This prevents the screw v turning around too far when operated by the ratchet mecha- a nism, and also from turning back when the parts of thi i mechanism resume their normal positions, Fig. 26. Turnin n the ratchet gear by this mechanism causes the builder screw v to turn, so that the nut q_{18} is drawn backwards, carrying wit t it, on account of its connections, the front builder shoe. Thi i shoe moving backwards causes the others to do the same. The upright arm q_{22} is thrown over toward the builder rai just as the carriage completes its outward run, so as t

cause the pawl to operate the ratchet gear, by a curved arm q_{14} carried by a bracket attached to the front part of the carriage square. The curved arm can be adjusted to give more or less throw to the pawl as required; it is usually set so that the pawl moves the ratchet gear 1 tooth.

The position that the nut q_{15} occupies at the beginning of a set of cops is determined by the adjusting screw q_{13}. The head of this screw comes against a projection q_{16} when the shoe is in its extreme forward position, and by turning the screw so that it does not project so far from the lug carrying the nut q_{15}, the shoe and nut can be moved farther forwards; when the amount of the screw projecting is increased, the forward movement of the shoe is decreased. The front end of the long rail may be raised or lowered, when required, by the adjusting screw q_{17}. Turning this screw so that it does not project so far above the rail causes the front end of the rail to be raised, while it is lowered when the screw projects farther, thus altering the length of the chase.

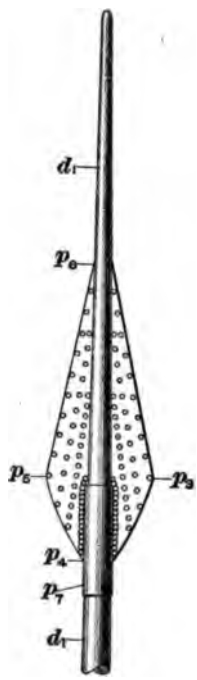


FIG. 27

56. The cop bottom is built up as shown in Figs. 24 and 27. The layers of yarn, being laid one on the other, cause the cop bottom to increase in diameter, while its base is conically formed by each layer being started a little higher than the preceding one. In the diagram, Fig. 27, four rows of small circles are shown on each side of the spindle, to represent layers during various periods in the formation of the cop bottom. These are not intended to accurately represent the actual number and position of the layers and coils of yarn, but to illustrate how the cop bottom is formed. The first layer, that is, the one nearest the paper tube p_7 and spindle d_1, extends just a short distance above the top of the paper tube. In this layer the coils, or spirals,

of yarn, represented by the small circles, are close together, so that all the yarn that has been delivered during the outward run of the carriage may be wound on the spindles. Since the surface on which the yarn is wound increases in length and also in the diameter at its lower portion as each layer is added, throughout the formation of the cop bottom, the coils must necessarily decrease in number and be farther and farther apart, because the length of yarn delivered for each stretch remains unchanged. This is shown diagrammatically in Fig. 27; the number of spirals decreases with each row of coils, while the space between the coils, or spirals, in each row gradually increases.

57. When a set of cops is first started, the builder rail is in its highest position, as the shoes occupy their outermost position, causing the studs supporting the rail to be on the highest portions of the shoes. The shoes are so shaped as to give the required positions to the rail during the building of the cops. The upper portion of each shoe is curved, as shown in Fig. 25, while the remaining portion is straight. During the formation of the cop bottom the rear end of the long rail will fall rapidly, while the front end will fall very slowly, on account of the construction of their respective shoes. The front end of the loose incline falls to about the same extent as the rear end of the long rail, because the inclinations of the rear portions of the upper surfaces of their shoes are about equal. The lowering of the rail in this manner causes the shoulder, or high portion, to which the rear end of the loose incline is pivoted, to be lowered to a less extent than the rear end of the long rail, thus producing the conical base $p_3\, p_4\, p_5$, Figs. 24 and 27, of the cop, as the lowering of the shoulder causes the winding faller to be slightly higher for each stretch. The lowering of the shoulder takes place slowly until the complete cop bottom is formed, when the front end of the rail lowers more rapidly, since the stud q_1, Fig. 25, passes over the shoulder of the shoe q_2 just as the cop bottom is completed.

The inclination, or pitch, of the loose incline, is greater

than that of the long one, and thus causes the winding faller to move quickly from the top to the bottom of the chase, so as to wind a few open spirals of yarn on the chase of the cop to act as a binding, Fig. 28, in order to produce a firm nose, a firm cop, and to prevent the yarn *slubbing off* when being unwound. This operation is frequently known as *crossing*.

58. Fig. 25 shows three principal stages, or positions, of the fallers during winding. Fig. 25 (*a*) shows their position just as the carriage starts on its inward run, indicated by arrow *1*, while arrow *2* shows the direction of motion of the winding faller at this stage. The winding faller continues its downward movement until the bowl q_{11} reaches the shoulder of the rail at q_9. Fig. 23 is a large view showing the position of the fallers and yarn just as the carriage starts on its inward run, while Fig. 28 shows the position of the fallers and yarn when the bowl q_{11} has reached the shoulder of the rail. The winding faller moves downwards quickly because the inclination of the short rail is considerable, as the distance from the starting point of the bowl q_{11}, Fig. 25 (*a*), to the shoulder of the rail is comparatively short. As the long rail is considerably longer than the short one, its inclination is, as a consequence, more gradual, and the direction of its inclination being opposite, the winding faller will rise gradually, as indicated by arrow *4*, Fig. 25 (*b*), while the carriage is continuing its inward run, indicated by arrow *3*. When

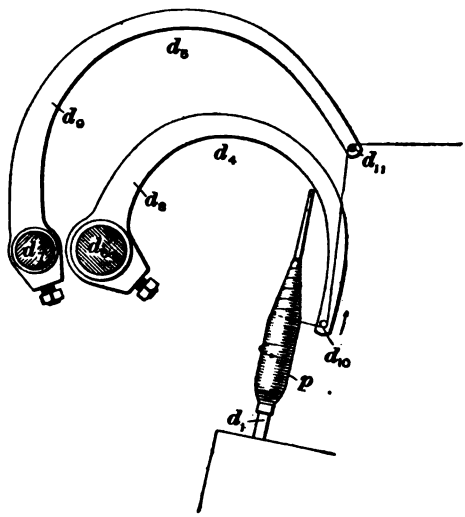


FIG. 28

the carriage has completed its inward run, arriving at position (*c*), the winding faller is at the top of the cop, as shown, winding being completed.

The speed of the carriage must also be taken into consideration in this connection. It starts in slowly and gradually increases in speed until about the middle of the inward run; then it gradually decreases. As the inclination of the long rail is gradually increased during the formation of the cop bottom, the chase is gradually lengthened until the bottom is completed, when the chase is longest. When winding first commences, the chase is only about $1\frac{1}{4}$ inches long, while at the completion of the bottom it is about $2\frac{1}{8}$ inches. These dimensions are approximate, since other lengths of chases are made for different sizes of cops, or even for the same size of cop.

59. When the stud q_1, Fig. 25, arrives at the shoulder of the shoe q_2, the bottom of the cop is completed and the formation of the body commences. The inclination of the surface of the shoe q_2, from the shoulder out, corresponds more nearly with the front portion of the shoe q_4 than do the rear upper portions of these shoes. Consequently, the lowering of both ends of the rail will be more nearly equal during the formation of the body. The inclination of the straight portion of the front shoe is a little greater than that of the rear shoe; consequently, the front end of the rail will lower a little more rapidly than the rear end, thus decreasing the inclination of the long incline and shortening the chase as the body forms. The chase at the completion of the set is $1\frac{3}{4}$ inches, as compared with $2\frac{1}{8}$ inches at the completion of the bottom, in the cop under description.

The loose incline is used for crossing and for regulating the position of the winding faller for locking. The long rail is used for regulating the position of the winding faller for winding the close spirals of yarn from the largest to the smallest diameter. The curved portions of the shoes are used for forming the cop bottom, while the straight portions are used during the formation of the body.

60. Driving of the Carriage.—The drawing in of the carriage is accomplished by the drawing-, or taking-, in bands, which are operated by the scrolls on the scroll shaft. The scroll shaft is driven by the drawing-in friction. Referring to Fig. 10, the scroll shaft g carries a large bevel gear g_{10} of 44 teeth, which is driven by a small bevel gear g_{11} of 10 teeth. The small bevel gear is compounded with the cone g_{12}. The outer, or inclined, surface of the cone, is covered with leather, so that when the conical shell g_{13}, which is revolving continuously and has an inclined inner face, is lowered into contact with the cone, the latter will revolve with the shell, being driven by frictional contact. The cone revolves around the upright shaft g_{14}, on which the conical shell is mounted and to which it is connected by having two downward-projecting lugs, each of which protrudes into an opening in a casting g_{15} keyed to the upright shaft. The upright shaft revolves continuously, and consequently the shell also, on account of its connection to the shaft. Attached to the upper end of this upright shaft is a bevel gear g_{16} of 24 teeth that is driven by a bevel gear g_{17} of 23 teeth attached to the taking-in shaft e_{11}, which is driven from the countershaft. During winding the drawing-in friction is thrown in so as to draw the carriage in to the beam, while during all other periods it is out.

Just as the carriage completes its outward run and depresses the front end of the long lever e_{10}, explained in connection with Fig. 7 (*d*), the cam-shaft operates the cams so that the cam e_{12}, Fig. 17, assumes a position opposite to that shown, and thereby depresses the forked end of the lever f_{10}. Near the forked portion of this lever is a projecting arm g_{18} that extends backwards sufficiently to pass under and support the adjacent end of the forked lever g_{19}, that is pivoted at g_{20}. This lever is the one that raises and lowers the conical shell, as it carries two studs, or pins, that project into the grooved hub. A spring g_{21}, connected to the opposite end of the lever and to the framing above, tends to draw up this end of the lever, depressing the opposite end and thereby putting in the friction. This is prevented until the

required time by a safety device, after the carriage has completed its outward run, and by the arm g_{30} supporting the opposite end of the lever g_{31}, in addition to the safety device, when the carriage is running out. The forked arm g_{30} of the lever g_{31} has an offset that projects beyond the hub of the conical shell; it carries a lug, or casting, r forming part of the safety device.

61. The Safety Device.—Fig. 29 is an elevation showing the three principal stages in the operation of this safety

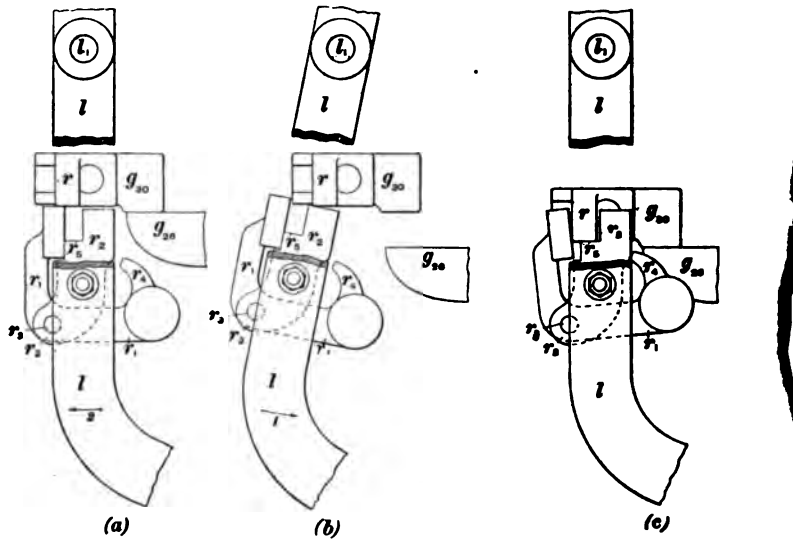


FIG. 29

device, the backing-off lever l, which supports some of the principal parts of this mechanism, being broken, so as to show their construction and operation. The positions illustrated in Fig. 29 are as seen when looking in the direction indicated by arrow *1* in Fig. 17. The backing-off lever carries a casting r_2, the upper portion of which is shaped as shown, while the lower portion extends downwards and outwards sufficiently to carry a stud r_3 for a pivot for the bell-crank lever r_1. The lower forward end of this lever is weighted

and carries an upward-projecting arm r_4 that prevents the front end of the lever turning too far, in an upward direction, when the upper end of the lever is pressed backwards so as to swing on its center. The weight is prevented, on the other hand, from forcing the front end of the lever downwards farther than shown in Fig. 29 (*a*), by the upper end of the lever resting against a shoulder of the casting r_2.

Fig. 29 (*a*) shows the position of the safety device during the period of drawing and twisting. In this case the arm g_{30} supports the arm g_{30}, and the lug r rests on the extreme upper portion of the lever r_1, the backing-off friction being out, and the backing-off lever l in an upright position.

The arm g_{30} being lowered by the action of the cam e_{30}, Fig. 17, assumes the position shown in Fig. 29 (*b*). The backing-off friction being thrown in, the backing-off lever swings in the direction indicated by arrow *1*, Fig. 29 (*a*), so that it occupies the position shown in Fig. 29 (*b*). This movement of the parts causes the extreme upper portion of the casting r_1 to swing under the lug r and support the arm g_{30}, so that the drawing-in friction cannot be thrown in until backing off is completed.

When backing off is completed, the backing-off lever swings in the direction indicated by arrow *2*, so that the backing-off friction will be thrown out, the lever assuming the position shown in Fig. 29 (*c*). The lever, in assuming this position, causes the extreme upper portion of the casting r_1 to pass from under the lug r, allowing the arm g_{30} to fall, so that the drawing-in friction is thrown in instantly. In this case the lug r rests on the shoulder r_3 of the casting r_2. The extreme upper end of the lever r_1 being higher than the highest portion of the casting r_2, it comes in contact with the side of the lug r when the backing-off lever is drawn forwards at the completion of backing off, and pushes it backwards, causing it to assume the position shown in Fig. 29 (*c*).

When drawing in is completed, the arm g_{30} is raised by the action of the cam e_{30}, Fig. 17. This arm being raised will cause the arm g_{27} to rise, thus disconnecting the friction,

and at the same time allowing the various parts of the safety device to return to their normal position.

62. The carriage cannot start in until it is unlocked by the raising of the catch k, Fig. 19 (a). This is accomplished by the connecting-rod k_2, which extends backwards and is connected at its rear end to the lower end of the lever k_6, pivoted at k_7. This lever has an arm k_8 connected to the forked lever g_3, that supports the conical shell of the friction by a connecting arm k_9. When the drawing-in friction is thrown in, the outer end of the arm k_8 is depressed, thus causing the lever k_6 to turn on its pivot, so that the lower end, to which the connecting-rod is attached, is thrown backwards, drawing with it the connecting-rod k_2, and thereby raising the catch and unlocking the carriage. This mechanism causes the carriage to be unlocked the moment the drawing-in friction is thrown in.

63. The carriage can be stopped during the inward run, when it is necessary, by depressing the outer end s_6 of the lever s, Fig. 19 (b). This lever is not shown in Fig. 19 (a), but it acts directly on the catch k and connecting-rod k_2. It is pivoted at s_1 and is operated by the pressure of the foot on the portion s_5, which is especially formed for this purpose. The inner end of the lever is weighted, while near the pivot is a shoulder s_3 in close proximity to a stud s_4 carried by the lower part of the catch k. When the outer end of the lever s is depressed by the foot, the inner end is raised, and the shoulder s_3 comes in contact with the stud s_4 forcing the lower end of the catch forwards, which carries with it the connecting-rod k_2. The forward movement of throws out the drawing-in friction until the pressure on the outer end of the lever s is released.

64. Driving of the Spindles.—During winding, the speed of the spindles must be gradually increased as the carriage runs in. This is true because the winding surface of the cop gradually decreases in diameter from the shoulder to the nose and as the carriage runs in the winding faller rising. While the cop bottom is being formed, the speed

the spindle must gradually decrease because the diameter of the cop bottom is constantly increasing, and as the stretch of yarn between the drawing rolls and the spindle is of the same length for each draw of the carriage, a decreased speed of the spindle is necessary to avoid breaking the yarn and to insure proper winding. As the cop approaches completion, the speed of the spindle must be increased slightly when the carriage nears the beam on account of the taper of the spindle, which reduces its diameter near its upper end and thus necessitates an increase in its speed to insure tight winding. The mechanism used to accomplish these objects

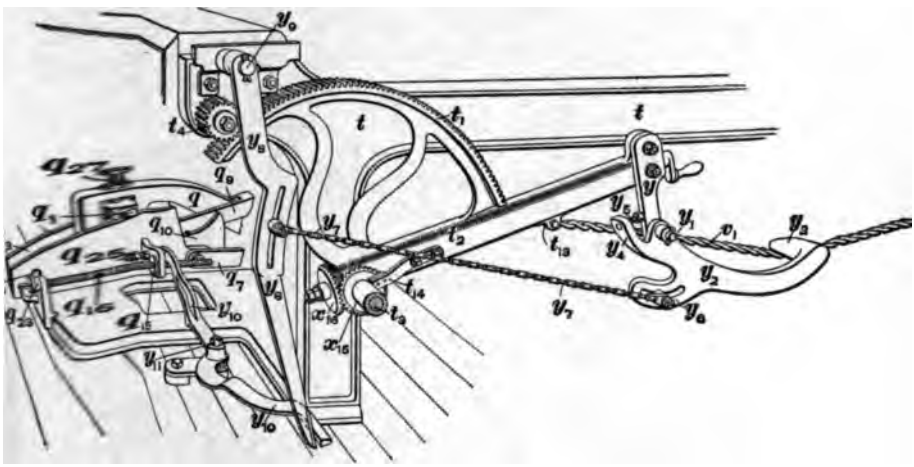


FIG. 30

is commonly known as the **quadrant**, a perspective view of which is shown in Fig. 30; although the quadrant does not actually drive the spindles, it is the controlling element. The driving of the spindles is accomplished as follows: The quadrant t, Figs. 30, 19 (a), and 31, consists of a segment, or quadrant, gear t_1 that is connected to an arm t_2, and supported by a short shaft, or stud, t_3. The quadrant is caused to turn back and forth on its center by a small spur gear t_4 of 19 teeth meshing with the segment gear. This spur gear is on a short shaft that extends across the headstock and

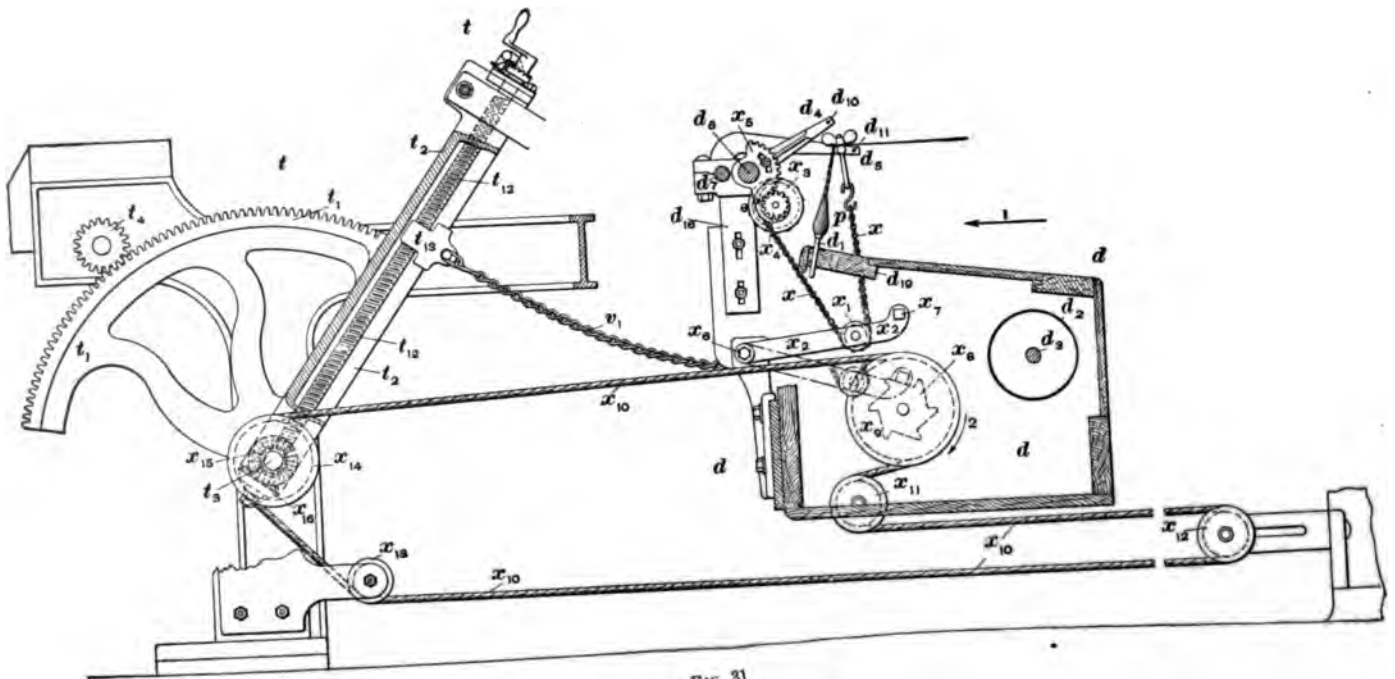

t
t
t
t1
t2
t4
t12
t13
t3
v1
x10
x15
x14
x16
x18
x10
d
d
d
d8
x5
d4
d10
d11
d5
x3
d7
d18
p
x
x4
d1
d10
x
x1
x7
x2
x3
x8
x9
2
x11
x10
x12
d2
d3
1

FIG. 31

ries, between the two upright portions of the framework, scroll t_4. The scroll is driven by bands t_6, t_7. The band t_6 attached at one end to the scroll, makes a few turns und it, then passes backwards around a guide pulley t_8, thence forwards to the stud and ratchet mechanism t_9, to ich the opposite end is attached. The ratchet mechanism carried by the central portion of the carriage. The other nd t_7 is attached to the scroll t_5 in a similar manner, makes ew turns around the scroll in the opposite direction to first one, then passes back over a stud t_{10}, and thence to stud and ratchet mechanism t_{11}, to which the opposite is attached. Both the stud t_{10} and the ratchet mechanism t_{11} are carried by the central portion of the carriage as well as the other ratchet mechanism.

As the carriage runs out the scroll is caused to revolve on account of the band connection, so that the band t_7 is wound up on the scroll and the band t_6 unwound, and vice versa when the carriage is running in, as the direction of rotation of the scroll is reversed. The running out of the carriage causes the gear t_4 to turn in such a direction as to cause the segment gear t_1 to turn forwards, thus raising the arm t_2 until it assumes an almost vertical position, which is the case at the beginning of the inward run.

65. The arm t_2, Fig. 31, is hollow and carries a long screw t_{12}, which is supported at each end. Mounted on the screw is a threaded **traveler** t_{13} that is caused to rise or fall according to the direction of rotation of the screw. The traveler is prevented from turning with the screw by a portion projecting through a slot, or narrow opening, in the face of the arm. The traveler is connected to a drum v, Figs. 19 (a) and 32, by a chain v_1, commonly known as the *winding chain*. The drum is carried by a short shaft in the carriage square, and is compounded with a large spur gear v_2 that meshes with a smaller spur gear v_3 loose on the cylinder shaft d_3. The spur gear on the cylinder shaft is compounded with a disk v_4. This disk carries a stud v_5, on which is pivoted a pawl v_6 that, during winding, is in contact

with a ratchet gear v_6 fast on the cylinder shaft. The end of the stud v_7 projects beyond the pawl an equal distance

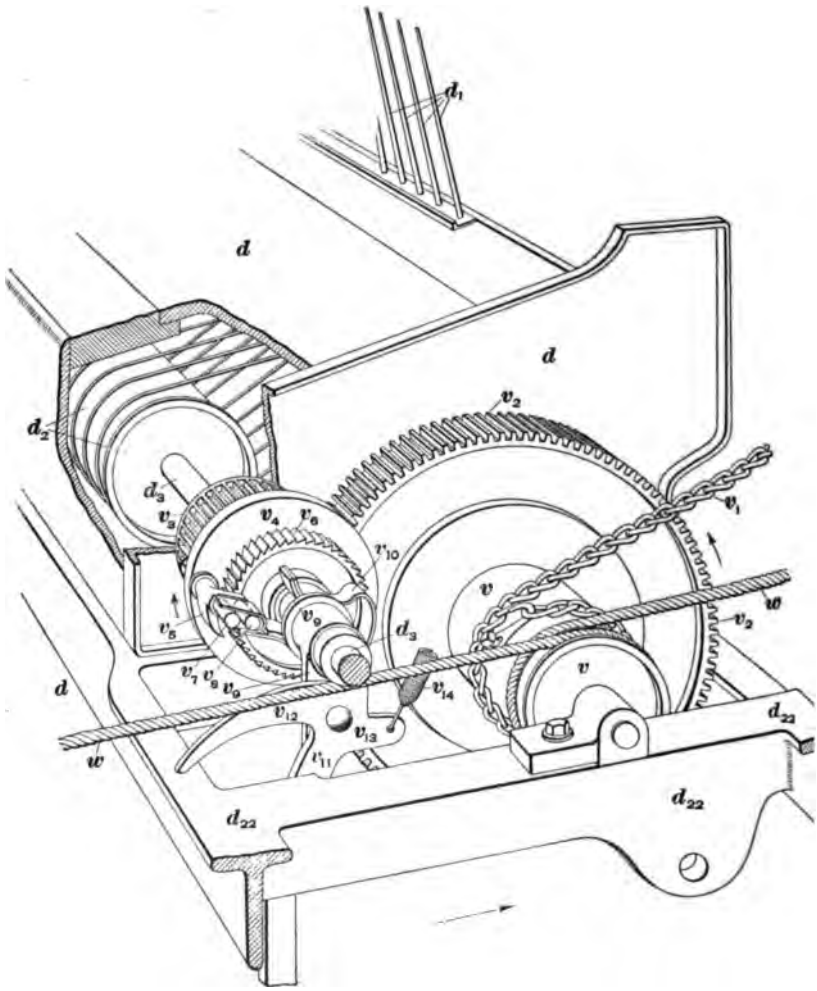


FIG. 32

with a stud v_8 carried by the arm of the pawl. Fig. 33 is a large view of the disk and ratchet mechanism.

Mounted loosely on the cylinder shaft, in close proximity to

the ratchet gear, is an arm v_8. The hub of this arm is grooved and supports a friction spring v_{10}, one end of which projects upwards and terminates in a fork that encloses the stud v_8; one of the tines of the fork is sufficiently long to come in contact with the stud v_7 that supports the pawl. Attached to the arm v_8, Fig. 19 (a), is a lever v_{11} that extends downwards. This lever has an arm v_{13} that projects backwards sufficiently to rest on the upper surface of the rear portion of the carriage square. The lever v_{11} has a short arm, or projection, v_{14} to which one end of the spring v_{14} is attached; the other end of the spring is attached to a stud carried by an upright portion of the carriage square. The tendency of the spring is to keep the inner end of the arm v_{13} resting on the upper surface of the rear portion of the carriage square. The lower portion of the lever v_{11} is slotted and fits over the end of a stud, or arm, v_{15} that is carried by a vertical arm supported by a bracket attached to one of the cross-beams of the carriage square.

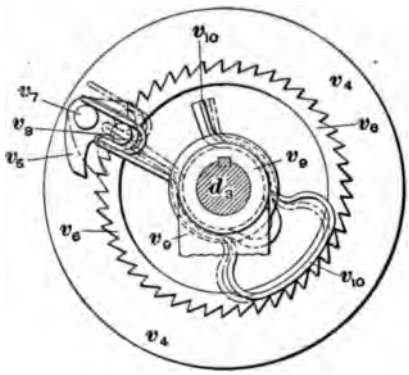


FIG. 33

When the carriage is out, the arm v_{13} is in close proximity to a dog v_{16} that is setscrewed to the connecting-rod k_3. When the drawing-in friction is thrown in, the connecting-rod moves backwards, thus bringing the dog v_{16} in contact with the arm v_{13}, which causes it to swing backwards and move the lower end of the lever v_{11} inwards against the tension of the spring v_{14}. This movement of the lever v_{11} causes the friction spring v_{15} to throw the pawl v_7 into contact with the ratchet gear v_8.

66. When the carriage is out, a considerable length of the winding chain v_1 is wound around the surface of the winding drum v. As the carriage runs in, as indicated by

arrow *1*, Fig. 19 (*a*), the chain unwinds from the drum, causing the latter to revolve, together with the gear v_2, in the direction indicated by arrow *2*, and as the large gear v_3 meshes with the small gear v_5, the small gear will revolve in the direction indicated by arrow *3*. The gear v_3 and disk v_4 being compounded necessitates the rotation of the disk with the gear when the latter rotates. The disk revolving and carrying the pawl v_6, which at this period is brought in contact with the ratchet gear v_8 by means of the spring v_{10}, causes the ratchet gear to revolve; and as the ratchet gear is attached to the cylinder shaft, the cylinder will revolve. The cylinder and spindles being banded, the direction of rotation of the latter depends on the direction of rotation of the cylinder, which in this case is the same as during the drawing-and-twisting period.

When the carriage has completed its inward run, the chain v_1 is almost entirely unwound from the drum v. The chain is rewound on the winding drum again during the outward run of the carriage by a *rewinding band* w. Referring to Figs. 19 (*a*) and 32, the rewinding band is attached to an arm w_1 at the rear of the headstock and passes forwards under a guide roll w_2, taking a turn over and around the grooved portion of the winding drum, and thence forwards to the front of the headstock, where it is attached to a weight lever w_3 that is pivoted at w_4. The tension, given to the band by means of the weight on the outer end of the lever, is for the purpose of producing friction between the winding drum and band sufficient to insure the revolving of the drum. When the carriage completes its inward run and starts on its outward movement, the rewinding band changes the direction of rotation of the winding drum v, causing the chain v_1 to be wound on its surface. Changing the direction of rotation of the drum also changes the direction of rotation of the gears v_2, v_3 and the disk v_4, consequently throwing the pawl v_6 out of contact with the ratchet gear v_8.

67. To illustrate, clearly, the working of the quadrant two diagrammatic views, Fig. 34 (*a*) and (*b*) are used. In

Fig. 34 (*a*), the winding drum v is shown in three positions, *1*, *2*, and *3*; *1* shows the winding drum in the position that it occupies just as the carriage starts to run in; *2*, when the carriage is about half way in; and *3*, when the carriage is in at the beam. The oblique lines v_1 represent the winding chain, while t_{13} is the traveler, and for the present is to be considered as stationary and occupying the position shown. The thin, or narrow, portions of the lines v_1 represent the

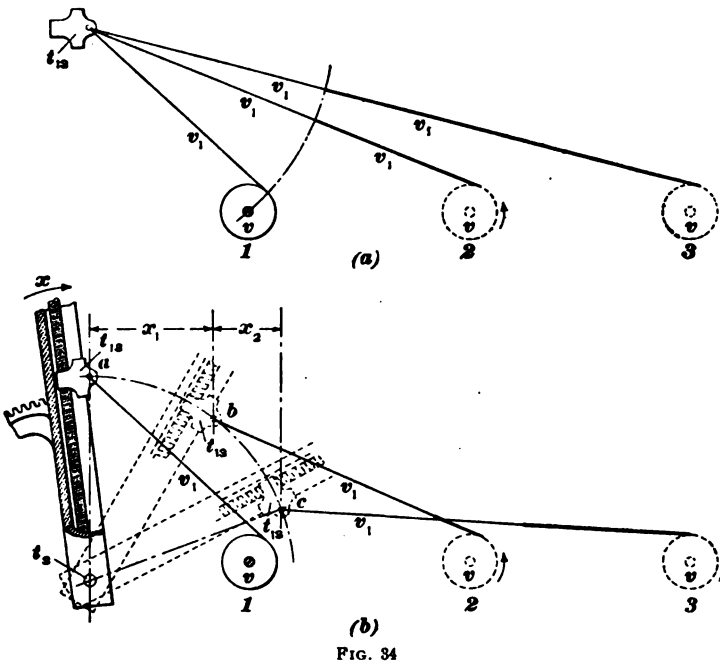


FIG. 34

amount of chain necessary to connect the traveler and the drum when the carriage is in its extreme outward position; while the thick portions represent the amount of chain that unwinds from the drum as the carriage runs in, occupying the second and third positions, respectively. By comparing the lengths of the heavy lines it will be seen that as the carriage runs in, the amount of the chain unwound increases. In other words, the length of chain unwound when the carriage has arrived in position *3* is more than twice that

unwound when in position *2*, notwithstanding the fac that the distance *1*, *3* is just twice that of *1*, *2*. Thi would tend to increase slightly the speed of the spindles a the carriage nears the beam, provided that the condition named existed. The drum rotates in the direction indicate by the small arrows as it moves inwards with the carriag and the chain unwinds.

Fig. 34 (*b*) shows approximately the actual conditions tha exist. In this case, the quadrant turns on its center t_3 in the direction indicated by arrow x as the carriage and the wind- ing drum move inwards. As the drum occupies positions *1*, *2*, and *3*, the traveler occupies positions *a*, *b*, and *c*, respect- ively. The traveler's moving forwards prevents as much chain being unwound from the drum, in assuming position *2*, as was the case when in the same position in Fig. 34 (*a*). The amount unwound is indicated by the heavy portion of the line v_1 and varies as the traveler subsequently is moved farther from the center t_3 of the quadrant arm during the for- mation of the cop bottoms. The amount of chain unwound from the drum as it assumes position *3*, Fig. 34 (*b*), and the traveler, position *c*, is also indicated by the heavy portion of the line v_1. By comparing the amount of chain unwound from the drum when arriving at positions *2* and *3*, it will be seen that the proportion is greater than in Fig. 34 (*a*); con- sequently, the increase in the speed of the drum is greater in proportion. Since the speed of the drum is greater, the speed of the spindles is greater, in order that the yarn may be properly wound on the cop as the diameter of its winding surface gradually decreases. The difference in the amount of chain unwound from the drum as it assumes position *3*, Fig. 34 (*b*), as compared with the amount unwound at position *2*, is due largely to the fact that the horizontal distance moved by the traveler is less in the second instance, as indicated by the distance x_2, than in the first instance, as indicated by the distance x_1.

68. When a set of cops is first started, the traveler t_{1_3}, Figs. 19 (*a*), 30, and 31, is in its lowest position on the screw t_{1_3},

Fig. 31, and the arm t_4 is almost vertical at the commencement of each layer. The arm is usually set a little forward of a perpendicular passing through the center of the stud t_3. The quadrant being in this position, with the traveler a little lower than the top of the winding drum, causes considerable chain to be unwound from the drum as the carriage runs in, because the pull is almost in a horizontal direction and the horizontal distance through which the traveler moves, as the quadrant turns downwards on its center, is very slight, thus causing more chain to be unwound from the surface of the drum than is the case when the traveler is higher up on the screw. The unwinding of the long length of chain causes the spindles to revolve quickly, in order to wind the yarn properly on the comparatively small diameter of the bare spindle.

As the cop bottoms increase in size, the speed of the spindles required, when winding on the yarn at the large diameter, is less than at the small diameter of the cops, consequently requiring a varying speed. As the traveler is moved farther from the center t_3 of the quadrant arm, the pull is no longer in a horizontal direction, and besides, it moves through a greater distance as the quadrant turns downwards. At the beginning of each new winding period the horizontal distance traversed by the traveler, as the carriage starts to run in, is gradually increased by the traveler being moved farther from the center of the stud t_3 of the quadrant arm; but as the carriage continues to run in, the distance traveled in a horizontal direction decreases by reason of the quadrant turning downwards as the carriage nears the beam, as explained in connection with Fig. 34 (*a*) and (*b*). Thus, in this case, only a slight amount of chain is unwound as the carriage starts to run in, the yarn winding on the large portion of the cops, but as the carriage nears the beam, the yarn is continually being wound on a smaller diameter of the cops, and more chain is unwound so as to increase the speed of the spindles, in order that the yarn shall be properly wound on the small part of the cops. When the cop bottoms are completed, the movement of the traveler along

the quadrant arm ceases. The traveler is not continually raised during the formation of the bottom, but periodically at the inward run of the carriage.

69. Cop-Bottom Governing Motion.—The turning of the quadrant screw t_{13}, Fig. 31, is governed by the fallers. Attached to one of the central arms of the counter faller is a chain x that passes downwards around a small pulley x_1, carried by the lever x_2 and then upwards to a scroll x_3, to which its opposite end is attached. Compounded with the scroll is a small spur gear x_4 that is operated by a segment gear x_5 mounted on the winding-faller shaft and attached to one of the central arms of the winding faller by a bolt and nut, so that any movement of the winding faller and shaft will be imparted to the segment gear. The lever x_2 carrying the pulley x_1 is pivoted at its outer end to the carriage at x_6, while the inner end carries a stud x_7. Immediately below the stud x_7 is a star, or ratchet, gear x_8 compounded with the band pulley x_9. An endless band x_{10} passes around this pulley, down, forward to, and around the guide pulley x_{11}, thence backwards and around another guide pulley x_{12}, forwards and around the guide pulley x_{13}, upwards and around the quadrant pulley x_{14}, and thence backwards to the pulley x_9. The guide pulley x_{11} is to give the band x_{10} a greater grip on the pulley x_9 than would otherwise be the case. When the carriage is running out, as indicated by arrow *1*, the band is stationary, but the band pulley x_9 is caused to revolve in the direction indicated by arrow *2*, on account of the motion of the carriage. A spring t_{14}, Fig. 30, attached to the side of the arm t_2 extends downwards and carries a friction pad at its lower end, which comes in contact with the outer surface of the gear x_{13}, preventing it from having too free a movement. The quadrant screw is prevented from turning backwards by a pawl and ratchet gear at the top of the quadrant arm. The ratchet gear is on the screw shaft.

During the drawing-and-twisting period, the lever x_2 is held in the position shown in full lines, but when backing off occurs, the winding faller lowers; thus the segment x_5 turns

downwards, causing the gear x_6 to turn in such a direction as to unwind a portion of the chain x from the scroll x_3. Unwinding the chain allows the lever x_2 to lower, so that the stud x_7 will come in the path of the teeth of the star gear x_8, as shown in dot-and-dash lines. The lever assuming this position prevents the pulley x_9 from turning and, consequently, holds the band at this point, thus causing it to move with the carriage.

As the carriage runs in, that is, in the direction opposite to arrow *1*, the quadrant pulley x_{14} will turn, being driven by the moving band, and as it is on a sleeve with the bevel gear x_{13} that meshes with the bevel gear x_{12} on the lower end of the screw f_{12}, the screw will turn and raise the traveler f_{13}.

The raising of the winding faller causes the shaft to turn the segment x_5, Fig. 31, upwards, thus causing the scroll to be turned so as to wind on a portion of the chain x; consequently, the lever x_2 is raised, thus allowing the star gear x_8 and the band pulley x_9 to rotate, and the band x_{10} to cease imparting motion to the quadrant pulley x_{14}. As the cops increase in size, less and less of the chain is unwound from the scroll x_3, as the extent of the downward motion of the winding faller continually decreases, while the cops increase until, when the cop bottoms are completed, the amount of chain unwound is insufficient to allow the lever x_2 to fall so that the stud x_7 can come in contact with the star gear x_8; consequently, the upward movement of the traveler ceases when the cop bottoms are formed.

A very important point in connection with the operation of this governing motion is the action of the counter faller, the position of which is controlled by the tension of the yarn. Since the chain x is connected to the counter faller, it is evident that the position of the counter faller will govern the length of time that the stud x_7 is in contact with the star gear x_8. This is true because when the tension of the yarn is greater than normal, the counter faller is lowered, thus allowing the stud x_7 to remain longer in contact with the gear x_8, while when the tension of the yarn is less than

normal the counter faller will rise, thereby drawing up on the chain and decreasing the length of time that x_7 is in contact with x_8. The longer the stud remains in contact with the gear, the greater will be the distance that the traveler t_{13} is raised by the rotation of the screw t_{12}, and vice versa. Hence, the tension of the yarn is kept uniform during the formation of the cop bottom, because the position of the counter faller aids in governing the movement of t_{13}.

70. During the formation of the body of the cops the spindles are driven as described, except that the traveler does not rise any higher on the quadrant screw, and a device must be applied to control the winding at the nose of the cops, on account of their decreasing size, due to the taper of the spindles. After the cop bottoms are formed, the upward movement of the traveler ceases, because the various diameters throughout the winding surfaces of the cops remain the same for each new layer of yarn as for the previous layer, except at the nose; consequently, the spindles must have the same speed for each new layer of yarn wound on as for the previous, except at the nose of the cop, when the speed must be slightly increased for each new layer.

71. Automatic Nosing Motion.—In order that the yarn may be wound on properly at the nose as the cop builds up, the **automatic nosing motion** is applied. At the top of the arm t_2, Fig. 30, is a cross-piece y, one end of which projects beyond the arm. Pivoted to the projecting portion of this piece at y_1 is an arm y_2. The outer portion of this arm has an offset y_3, generally called the **nosing peg,** that comes in contact with the winding chain v_1. Near the pivot of the arm y_2 is a projection y_4 carrying an adjusting screw y_5 for raising or lowering the nosing peg as required. The arm y_2 also has a slotted projection y_6, to which is attached one end of the *monkey chain* y_7. The other end of the monkey chain is attached to the central portion of a long pendent lever y_8 that is pivoted at its upper end to the front of the headstock at y_9. The lower end of this lever comes in contact with one end of a horizontal lever y_{10} that is pivoted at y_{11}. The

opposite, or left-hand, end of this lever comes in contact with the projection of the front shoe of the builder motion that engages the nut q_{1a}.

As the cops increase in size the shoe moves backwards, and as the left-hand end of the lever y_{1a} is in contact with the inner side of the projection of the front shoe, this end of the lever will be moved backwards and the right-hand end moved forwards. This movement of the lever y_{1a} causes the lower end of the lever y_a to be moved forwards slightly for each stretch. The forward motion of the lower end of this lever causes some of the slack that exists during the formation of the cop bottoms to be taken out of the monkey chain, so that when the quadrant turns down as the carriage nears the beam, the chain becomes tightened and causes the nosing peg y_a to depress the winding chain v_1 below its horizontal position, thereby causing more chain to be unwound from the winding drum, thus increasing the speed of the spindles as the yarn winds on at the nose of the cop.

As the cops build up and the shoes move backwards, more and more slack is taken out of the monkey chain, causing the nosing motion to be more and more *keen* for each new winding period. During the formation of the cop bottoms, the monkey chain is slack, as the projection of the front shoe q_a has not moved backwards a sufficient distance to operate on the end of the lever y_{1a} so as to affect y_a, and the weight of the rear end of the nosing-peg lever y_a alone is not sufficient to depress the winding chain v_1 during winding, since this chain is under considerable tension; consequently, the monkey chain must be tightened, so that the nosing peg will depress the winding chain, to increase the speed of the spindles.

72. Winding being completed when the carriage reaches the beam, reengaging occurs. The length of time consumed during the winding period is about $3\frac{1}{2}$ seconds in the case under consideration.

REENGAGING

73. **Reengaging** is the fourth period in the cycle of operations of the mule, and when it is completed the drawing-and-twisting operation, which is the first in the cycle of operations, takes place. The object of this period is to prepare the various parts for the positions that they must occupy during the outward run of the carriage. This necessitates the reversing of certain parts from the positions that they occupy during the inward run.

74. The fallers must be changed so that the winding-faller wire will be above the yarn and the ends of the

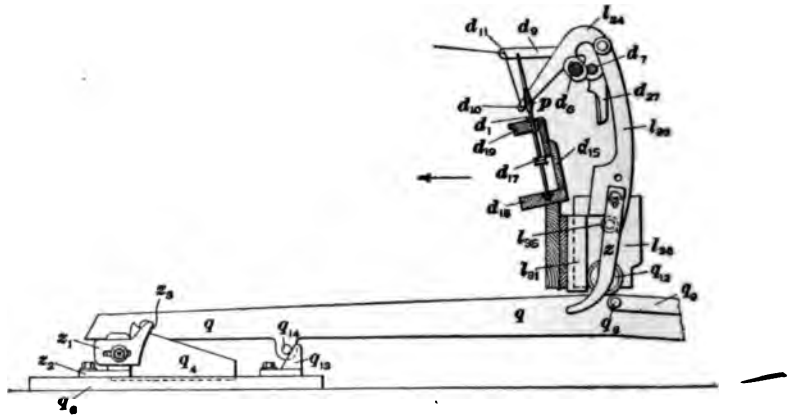


FIG. 35

spindles, and the counter-faller wire below them. Both faller wires must be out of contact with the yarn, in order that the latter shall have free passage from the rolls to the ends of the spindles during drawing and twisting. The fallers assuming this position allow the yarn to be wound on the spindle blades in open spirals between the noses of the cops and the ends of the spindles so that twisting may take place.

As the winding faller is locked in order to control the winding of the yarn, it must be unlocked in order that the wire may rise so as to be above the ends of the spindles and

out of contact with the yarn. The unlocking of the winding faller is caused by removing the lower surface of the boot leg l_{33}, Fig. 35, from contact with the bowl l_{34} on which it rests. The removal of the boot leg from the position shown in Fig. 35 is accomplished by the lever z that is attached to its lower portion. Just as the carriage completes its inward run, the lower, or curved, portion of the lever z comes in contact with the curved face of the arm z_1 that is supported by the bracket z_2. This arm and bracket are stationary, although the arm can be adjusted. The lower portion of the lever z coming in contact with the face of the arm z_1 causes the boot leg to be thrown off the bowl l_{34}.

When a set of cops is first started, the builder rail q being in its highest position, the lower end of the lever z will come in contact with the face of the arm z_1 at about the point z_3. As the builder rail q, the sliding casting l_{36}, and boot leg l_{33} are lowered as the cops increase in size, the lever z will be lowered; consequently, the lower end of this lever will come in contact with the face of the arm z_1 below the point z_3. As the face of the arm is curved so that its lower portion, near the floor, is farther from the front of the mule than the portion near the point z_3, the unlocking of the winding faller will occur later and later as the cops increase in size. This is desirable because the distance between the noses of the cops and the upper ends of the spindles gradually decreases as the cops build up, thus requiring less yarn for the open spirals on the blades of the spindles to bring the yarn in position for twisting, during the outward run of the carriage. As soon as the boot leg is off the bowl l_{34}, the winding-faller wire d_{14} rises very quickly, on account of the tension of the springs j_{13}, Fig. 18, so that a few open spirals of yarn are allowed to wind on the blades of the spindles between the noses of the cops and the ends of the spindles.

Just as the carriage *strikes in*, or reaches the roll beam, the levers similar to j_3, Fig. 18, which were supported by the inclines similar to j_{14} during backing off, are supported by the under side of the levers coming in contact with the bowls similar to j_{15} carried by the brackets similar to j_{16}.

This reduces the weight on the counter faller, and consequently the tension on the yarn, until the winding faller has risen to its proper position and until the weight of all the levers similar to j_1 is supported by chains similar to j_{10}. The counter faller now being relieved of any weight, or pull, of the levers j_1 falls, by its own weight, until its downward motion is checked by the chains similar to j_3. The tension on these chains is simply that caused by the weight of the counter faller itself.

The counter faller is prevented from jumping up and breaking the yarn, when the carriage strikes in, by the face of a downward-projecting arm d_{17}, Fig. 35, coming in contact with a stud on the side of the framework of the headstock near the back of the mule. The arm d_{17} is situated near the boot leg l_{11}, and is cast in one piece with one of the inner end supports of the counter-faller wire, as shown in Fig. 7 (*a*).

75. Reversal of Parts and Disengaging of Catches. When the carriage strikes in, it must stop and then recede from the rolls, since the yarn that was previously spun is wound on the spindles and more must be delivered and twisted before winding can again take place. Just as the carriage strikes in, the inner end of the long, or steeple, lever e_{11}, Fig. 7 (*d*), is depressed, so that the cam-sleeve e_1, Fig. 7 (*a*), can make half a revolution, assume the position shown, and thus allow the cams to cause the parts that they control to assume the proper positions for the drawing-and-twisting period.

The cam e_{10}, Figs. 7 (*a*) and 17, turns so as to raise the forked end of the lever f_{11} and cause the arm g_{20}, Figs. 17 and 29 (*c*), to raise the arm g_{10}, thus lifting the conical shell g_{21} from the drawing-in friction, so that it ceases to operate the screw-shaft g, Fig. 10. The raising of the arm g_{10}, Figs. 17 and 29 (*c*), causes the backing-off locking, or safety, device to assume its normal position, shown in Fig. 29 (*a*). As this mechanism assumes its normal position, it locks the drawing-in friction so that it cannot operate until backing is completed.

A safety device is also provided so that the drawing-in friction will be disengaged at the completion of the inward run of the carriage, should the cam-and-lever connection fail. This device is shown in Fig. 19 (*a*) and consists of a screw d_{28} carried by the rear portion of the carriage square, so that its head will come in contact with the face of the upper portion k_{10} of the lever k_8 and press it backwards. This will cause the lever k_8 to swing on its center so that the arm k_8 will be raised, and as it is connected to the forked lever g_{27} by the arm k_{9}, it will raise the forked portion of this latter lever, thus causing the friction to be disengaged.

The parts c_{29}, c_{30} of the front-roll clutch, Fig. 7 (*a*), will be thrown into contact, as the spring c_{33} keeps the lower portion of the lever c_{31} in contact with the face of the cam e_{23}, which at this time is turned around so that the lowest portion of its face is in contact with the lever, as shown. This causes the rolls to revolve for drawing and delivering the stock.

The parts f_6, f_7 of the back-shaft clutch, Fig. 17, will be thrown into contact as the end of the lever f_{27}, carrying the projection f_{26} is lowered, through the action of the cam e_{25}, lever f_{24}, and spring f_{25}. The throwing in of these clutch parts allows the back shaft to revolve when the front roll begins to turn and thus cause the carriage to recede from the rolls.

76. Shipping of Belt.—The turning of the cam e_{26}, Figs. 7 (*a*) and 16 (*a*), so that its highest part is in contact with the arm h_8, causes the driving belt a_8 to be shipped from the loose to the tight pulley, as it has been on the loose pulley during backing off, winding, and reengaging.

The belt is partly shipped after the cops are about half built, so that the speed of the spindles will be increased just as the carriage strikes in each time, in order to prevent snarling when the fallers change and also so that the spindles may run at almost their normal speed for twisting, so that there will be practically no lost time during reengaging nor loss in twist at the commencement of spinning. The mechanism for the accomplishment of this partial shipping

of the belt is frequently termed the **hastening, or anti-snarling, motion,** and is operated and controlled by the builder rail.

Pivoted at i to the upper portion of the casting l_{28}, Fig. 25, position (b), is a short arm i_1 that is attached at its upper end to the outer end of the lever i_2 at i_3. This lever is pivoted to a portion of the carriage near the square at i_4, while the inner end supports an arm, or upright support, i_5 that is attached to the front end of the rail i_6. The rail is pivoted at its rear end to the carriage at i_7 and projects above the upper surface of the carriage body. The upper surface of the portion of the rail extending above the carriage is inclined. As the cops build, the builder rail and casting l_{28}, in lowering, cause the outer end of the lever i_2 to lower and the inner end to rise, thus raising the rail i_6 so that it extends farther and farther above the carriage. Just before the carriage completes its inward run, the inclined surface of the rail i_6 comes in contact with the under side of a projection h_{27}, Fig. 16 (a), carried by the arm h_7, thus slightly raising the outer end of this arm and causing the belt a_6 to be moved sidewise slightly, so that a portion of the belt will be on the tight pulley a_7, while the greater portion will be on the loose pulley a_8. This partial shipping of the belt causes the tight pulley to revolve. Since the rail rises higher and higher as the cops build, this action will be made more and more keen; that is, it will move the belt farther and farther on to the tight pulley.

77. When the belt is shipped to the tight pulley and the various mechanisms are ready for the outward run, drawing and twisting takes place. The time consumed by the reengaging period is only about $\frac{1}{2}$ second—this period requires less time than any other. The total length of time consumed by all the periods during one complete cycle is only about 15 seconds in the case under consideration, as previously stated.

DOFFING

78. Doffing is the removal of the full, or completed, cops and the preparing of the machine for the formation of a new set. On the mule this operation requires at least two persons, although more can be advantageously employed. From the description of the actions of the mule, it will be noticed that it continues in operation whether the belt is on the tight pulley a_7, Fig. 7 (*a*), or on the loose pulley a_8; also, that the belt must be on a certain one of these pulleys during certain periods in the actions of the mule.

The only way of stopping the entire mule, which is necessary during doffing, as well as at other times, is by shipping the counter belt from the tight pulley on the countershaft to the loose one, thereby allowing the countershaft to stop. In order to allow the belt to be shipped from the tight pulley on the countershaft to the loose one, or vice versa, the driving pulley on the main driving shaft a_7, Fig. 5, has a wide face. The belt is shipped from one pulley to the other by a rod-and-lever connection, a portion of this mechanism being shown in Fig. 1. The setting-on handle o is connected to the front end of the rod o_1, which extends backwards, being connected at its rear end to the downward-projecting arm of the lever o_2 that is pivoted at o_3. The upward-projecting arm of this lever is connected to the lower end of a vertical rod o_4. This vertical rod extends upwards to the remainder of the belt-shipping mechanism in front of the countershaft. By moving the setting-on handle and rod in or out, the belt is shipped from the loose to the tight pulley, or vice versa. When the setting-on handle and rod are in the position shown in Fig. 1, the countershaft is stopped.

When a set of cops has reached the desired size, the counter belt is thrown on the loose pulley just as the carriage completes its last outward run, since there is enough momentum to allow the mule to back off, and the carriage to run in a part of the way. The carriage is stopped when the bowl of the winding faller reaches the shoulder, or

highest part, of the builder rail, by throwing out the drawing-in friction. When the bowl is in this position, the winding faller has completed its downward movement, being at the shoulder of the cops, and the binding, or open, spirals, of yarn have been wound on the chase of the cops.

79. In order to allow the fallers to be lowered so that they occupy the position shown in Fig. 36, the rim band

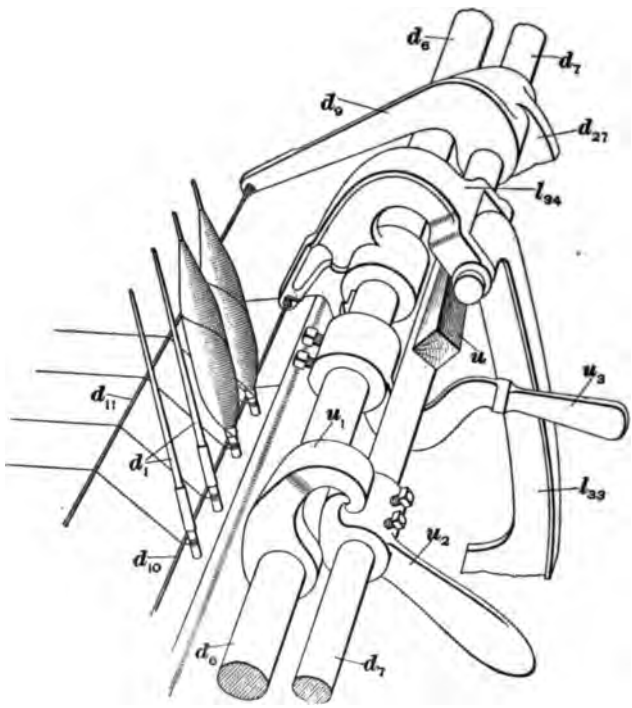


FIG. 36

must be turned back by hand, that is, in the opposite direction to that in which it moves during drawing and twisting, so that the lower spirals of the binding layer will be slackened enough to allow the yarn to be drawn down around the body and base of the cops, as shown, when the fallers are depressed. The winding faller is held down in the position

shown by inserting a block of wood u between the counter-faller shaft and the portion of the arm l_{14} to which the boot leg l_{13} is attached. The counter faller is held down by the hook, or catch, u_1, which is mounted loosely on the winding-faller shaft, but which can be moved along the shaft and turned so that the hooked portion comes in contact and locks with the hooked portion of the handle u_2. The handles u_3, u_4 are used for depressing the fallers by hand.

The quadrant screw is now turned by removing the pawl from contact with the ratchet gear at the top of the quadrant arm and turning the screw back by the crank-handle at the top of the screw shaft so that the traveler will occupy its lowest position, which is the one necessary for starting a new set of cops. The winding chain should also be slackened as the quadrant traveler is reset, but it should be tightened again before the carriage is run in for doffing. The builder motion should be reset so that the shoes will be in their foremost position, as required, when starting a new set of cops. The shoes are moved forwards by turning the builder screw backwards by a crank-handle placed on the squared portion of the outer end of the screw, as shown in Fig. 26. Before the screw can be turned back, however, the pawl must be removed from contact with the ratchet gear on the inner end of the screw.

After these parts have been set, the fallers are depressed and locked as stated, when the drawing-in friction is thrown in and the counter belt shipped on to the tight pulley for a moment so as to allow the carriage to run in for about 3 inches; the belt is then thrown on to the loose pulley again and the drawing-in friction thrown out. The carriage moving in for this short distance allows a few coils of yarn to be wound on the spindles just below the paper tubes on which the cops are formed. The cops are now removed and packed in a doffing box, frequently called a *filling box*.

80. As the cops are being removed, a fresh supply of paper tubes are placed on the spindles, one tube to each spindle. Before the tubes are forced down in position, the

wooden block, or wedge, u should be removed to allow the winding faller to rise slightly to assume its proper position for winding, which is controlled by the builder rail and bowl. The tubes are now forced down in position on the spindles, so that their tops will be in line, by a wooden tube setter, which is made to fit against the spindles.

The checking band should be tightened somewhat by turning the hand wheel situated at the front of the headstock for this purpose. Tightening this band prevents the carriage from striking in too hard, which would cause it to rebound, thus straining and breaking the yarn, as well as straining the carriage and other parts. One person now releases the counter-faller catch u_1, while another holds the counter faller in the position shown. This prevents the counter faller from rising and straining or breaking the yarn. The person that released the catch generally sets in the drawing-in friction, so that the carriage and parts will be in position to continue the inward run and the winding of the yarn suspended between the spindle ends and the rolls. The counter belt is now gradually shipped to the tight pulley so that the carriage will start in slowly. As the carriage runs in, the counter faller is allowed to rise gradually, so as not to strain the yarn. After the mule has run a short time for building a new set of cops, the checking band can be slackened again until it regains its normal tension.

COTTON MULES

(PART 2)

MANAGEMENT

CALCULATIONS

SPEEDS

1. The calculations for the mule refer principally to speeds, drafts, twist, production, changes in the sizes of gears, etc. In a number of cases where the calculations resemble those of previously described machines the rules are omitted. The necessary data for the following calculations are given in Fig. 1 and in the text of this and the preceding Section.

In most cases machines are continuous in their actions, and their speeds are calculated in revolutions per minute, but the mule is intermittent and very few parts are revolving continuously for more than a brief period of time. Since the length of time that the different parts are in action varies, some definite unit of time must be taken, in order that the relative speeds of the various parts may be calculated; therefore, the usual method is followed and the number of revolutions per minute is taken as a base.

2. Countershaft.—Since the various parts of a mule receive motion, either directly or indirectly, from the countershaft, the determination of its speed is important. The

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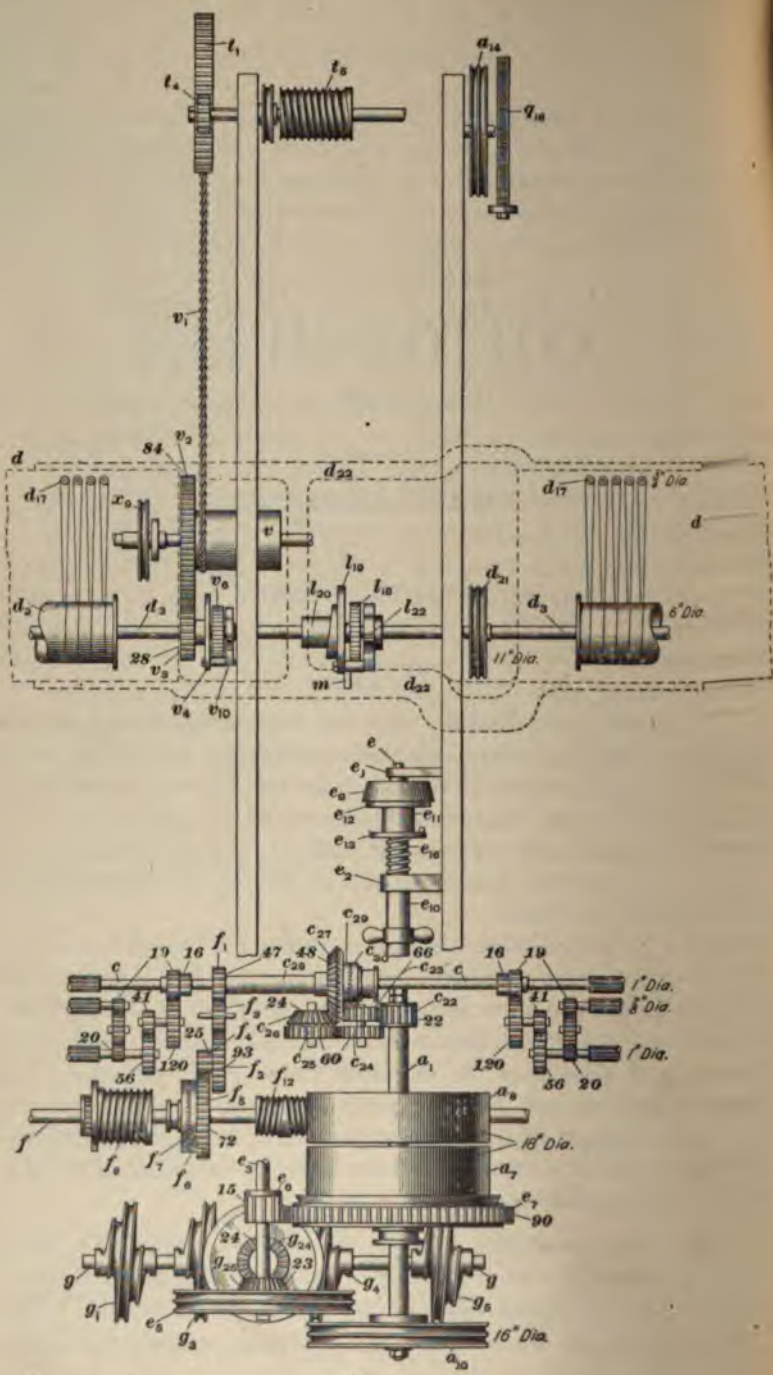


FIG. 1

following example illustrates the method of finding the speed of the countershaft:

EXAMPLE.—Find the number of revolutions per minute of the countershaft when the main driving shaft makes 310 revolutions per minute and carries a 35-inch pulley driving a 19-inch pulley on the countershaft.

SOLUTION.— $\frac{310 \times 35}{19}$ = 571.052 rev. per min. of the countershaft. Ans.

3. **Rim Shaft.**—The rim shaft is the main driving shaft of the mule and receives its motion from the countershaft; its speed is determined as shown by the following example:

EXAMPLE.—Find the number of revolutions per minute of the rim shaft when the countershaft makes 571.052 revolutions per minute and carries a 28-inch pulley driving an 18-inch pulley on the rim shaft.

SOLUTION.— $\frac{571.052 \times 28}{18}$ = 888.303 rev. per min. of the rim shaft. Ans.

4. **Spindles.**—In mule spinning, the speed of the spindles is of the utmost importance, being ascertained as follows:

EXAMPLE.—Find the number of revolutions per minute of the spindles, making a deduction of 5 per cent. for slippage, etc., when the rim shaft makes 888.303 revolutions per minute and carries a 16-inch rim pulley driving an 11-inch pulley on the cylinder shaft. The cylinder is 6 inches in diameter and drives a $\frac{3}{4}$-inch whorl on the spindle.

SOLUTION.— $\frac{888.303 \times 16 \times 6}{11 \times \frac{3}{4}}$ = 10,336.616 rev. per min. 5 per cent. of 10,336.616 = 516.830. 10,336.616 − 516.830 = 9,819.786 rev. per min. of the spindles. Ans.

The allowance of 5 per cent. made in this example for slippage of the bands, belts, etc. is not absolute, as it depends largely on the condition of the bands, belts, and other parts, but it is the allowance usually made.

5. To find the number of revolutions of the spindles to 1 revolution of the rim shaft when the number of revolutions of the spindles for a given time and the number of revolutions of the rim shaft for an equal length of time are known:

Rule I.—*Divide the number of revolutions of the spindles by the number of revolutions of the rim shaft.*

EXAMPLE 1.—Find the number of revolutions of the spindles to 1 revolution of the rim shaft when the spindles make 9,819.786 revolutions per minute and the rim shaft makes 888.303 revolutions per minute.

SOLUTION.— $9{,}819.786 \div 888.303 = 11.054$ rev. of the spindles to 1 rev. of the rim shaft. Ans.

To find the number of revolutions of the spindles to 1 revolution of the rim shaft when the diameters of the rim pulley, cylinder pulley, cylinder, and whorl are known:

Rule II.—*Divide the product of the diameters, in inches, of the rim pulley and cylinder by the product of the diameters, in inches, of the cylinder pulley and whorl.*

EXAMPLE 2.—Find the number of revolutions of the spindles to 1 revolution of the rim shaft, with a deduction of 5 per cent. for slippage of the bands, belts, etc., when the rim pulley is 16 inches in diameter, the cylinder pulley 11 inches, the cylinder 6 inches, and the whorl $\frac{3}{4}$ inch.

SOLUTION.— $\frac{16 \times 6}{11 \times \frac{3}{4}} = 11.636$ rev.; 5 per cent. of $11.636 = .581$. $11.636 - .581 = 11.055$ rev. of the spindles to 1 rev. of the rim shaft. Ans.

6. Front Roll.—The number of revolutions per minute of the front roll must be determined since the speed of the front roll, together with its diameter, governs the speed at which the stock is delivered by it. The following examples illustrate the method of finding the revolutions per minute of the front roll and also the number of inches of stock that it delivers per minute:

EXAMPLE 1.—Find the number of revolutions per minute of the front roll when the rim shaft makes 888.303 revolutions per minute and carries a 22-tooth gear driving a 66-tooth gear on a short sleeve. On this same sleeve is a 60-tooth gear that drives a 60-tooth gear that is compounded with a 24-tooth bevel gear. The 24-tooth gear drives a 48-tooth bevel gear on a sleeve on the front roll. This bevel gear is compounded with one-half of a toothed clutch, the other half of which is fastened to the shaft of the front roll.

SOLUTION.— $\frac{888.303 \times 22 \times 60 \times 24}{66 \times 60 \times 48} = 148.05$ rev. per min. of the front roll. Ans.

EXAMPLE 2.—Find the number of inches of stock delivered per minute by the front roll when the roll is 1 inch in diameter and makes 148.05 revolutions per minute.

SOLUTION.— $148.05 \times 1 \times 3.1416 = 465.113$ in. per min. Ans.

TWIST

7. There are a number of methods of finding the amount, or number of turns per inch, of twist being inserted in the yarn, but the principal one is to take into consideration the connecting pulleys, gears, etc. between the front roll and the spindles. There are also a number of methods of finding the proper amount of twist to be inserted in any given yarn; the principal one requires the consideration of the counts and class of yarn to be spun and the standard multiplier for that class of work.

8. In order to find the number of turns of twist being inserted in the yarn according to the method stated, the following rule may be applied:

Rule I.—*Assuming the front-roll gear to be a driving gear, divide the product of the driving gears and the diameters, in inches, of the rim pulley and cylinder by the product of all the driven gears and the diameters, in inches, of the cylinder pulley, whorl, and the front roll multiplied by 3.1416 to give its circumference.*

EXAMPLE 1.—Find the number of turns of twist per inch being inserted in the yarn, with a deduction of 5 per cent. for slippage of bands, belts, etc., according to the data given in Fig. 1.

SOLUTION.— $\frac{48 \times 60 \times 66 \times 16 \times 6}{24 \times 60 \times 22 \times 11 \times \frac{3}{4} \times 1 \times 3.1416} = 22.223$. 5 per cent. of 22.223 = 1.111. $22.223 - 1.111 = 21.112$, turns of twist per in. Ans.

To find the number of turns of twist per inch being inserted in the yarn when the number of revolutions per minute of the spindles and the number of inches of stock delivered per minute are known:

Rule II.—*Divide the number of revolutions per minute of the spindles by the number of inches of stock delivered per minute by the front roll.*

EXAMPLE 2.—Find the number of turns of twist per inch being inserted in the yarn when the spindles make 9,819.786 revolutions per minute and the front roll delivers 465.113 inches of stock.

SOLUTION.— $9{,}819.786 \div 465.113 = 21.112$, turns of twist per in. Ans.

9. The twist is generally altered by changing the rim pulley or the speed gear. The speed gear is the one changed under ordinary conditions, which require only a slight alteration in the amount of twist, but for a considerable change the rim pulley is altered; in extreme cases both are changed. Referring to Fig. 1, the spur gear c_{22} of 66 teeth driven by the 22-tooth gear c_{22} on the front end of the rim shaft is the speed gear.

To find the constant for twist for the rim pulley when the sizes of the gears, pulleys, etc. are known:

Rule I.—*Perform the calculations in exactly the same manner and select exactly the same data as when finding the twist, except that the rim pulley should be considered as 1 inch in diameter.*

EXAMPLE 1.—Find the constant for twist for the rim pulley according to the data given in Fig. 1.

SOLUTION.— $$\frac{48 \times 60 \times 66 \times 1 \times 6}{24 \times 60 \times 22 \times 11 \times \frac{3}{4} \times 1 \times 3.1416} = 1.3889, \text{ constant.}$$ Ans.

To find the constant for twist for the speed gear when the sizes of the gears, pulleys, etc. are known:

Rule II.—*Perform the calculations in exactly the same manner and select exactly the same data as when finding the twist, except that the speed gear should be considered as having only 1 tooth.*

EXAMPLE 2.—Find the constant for twist for the speed gear c_{22} according to the data given in Fig. 1.

SOLUTION.— $$\frac{48 \times 60 \times 1 \times 16 \times 6}{24 \times 60 \times 22 \times 11 \times \frac{3}{4} \times 1 \times 3.1416} = .3367, \text{ constant.}$$ Ans.

To find the number of turns of twist per inch being inserted in the yarn when the constant for the rim pulley and the size, or diameter, of the rim pulley are known:

Rule III.—*Multiply the diameter of the rim pulley being used by the constant for twist for the rim pulley.*

EXAMPLE 3.—Find the turns of twist per inch being inserted in the yarn, making a deduction of 5 per cent. for slippage of bands, belts, etc., when a 16-inch rim pulley is used and the constant is 1.3889.

SOLUTION.— $16 \times 1.3889 = 22.222$. 5 per cent. of $22.222 = 1.111$. $22.222 - 1.111 = 21.111$, turns of twist per in. Ans.

To find the number of turns of twist per inch being inserted in the yarn when the constant for the speed gear and size of the speed gear are known:

Rule IV.—*Multiply the size of the speed gear being used by the constant for twist for the speed gear.*

EXAMPLE 4.—Find the turns of twist per inch being inserted in the yarn, making a deduction of 5 per cent. for slippage of bands, belts, etc., when a 66-tooth speed gear is being used and the constant is .3367.

SOLUTION.— $66 \times .3367 = 22.222$. 5 per cent. of $22.222 = 1.111$. $22.222 - 1.111 = 21.111$, turns of twist per in. Ans.

To find the diameter of the rim pulley being used when the calculated twist and the constant for twist for the rim pulley are known:

Rule V.—*Divide the number of turns of twist per inch by the constant for twist for the rim pulley.*

EXAMPLE 5.—Find the diameter of the rim pulley required to produce 22.223 turns of twist per inch when the constant for twist for the rim pulley is 1.3889.

SOLUTION.— $22.223 \div 1.3889 = 16$ in., dia. of rim pulley. Ans.

To find the size of the speed gear being used when the calculated twist and the constant for twist for the speed gear are known:

Rule VI.—*Divide the number of turns of twist per inch by the constant for twist for the speed gear.*

EXAMPLE 6.—Find the size of the speed gear required to produce 22.223 turns of twist per inch when the constant for twist for the speed gear is .3367.

SOLUTION.— $22.223 \div .3367 = 66.002$, or practically a 66-tooth gear. Ans.

10. To find the twist to be inserted in a certain class of yarn, the square root of the counts to be spun and the standard multiplier for that class of work must generally be known,

in which case the square root of the counts is multiplied by the standard multiplier. The standard multiplier varies for different classes of work and kinds of cotton; the following are not absolute, but are given as a guide: For warp and filling yarns spun from American cotton, 3.75 and 3.25, respectively, are used; for Egyptian cotton, 3.6 and 3.18, respectively; and 2.75 for filling yarns spun from sea-island cotton. For hosiery yarns the multiplier ranges from 2.25 to 2.6, as hosiery yarns are softer than weaving yarns and require less twist. Long stock does not require as much twist as short stock, nor combed stock as much as carded stock. In many cases the constant multiplier is given with each order, especially with those for hosiery yarns.

EXAMPLE.—Find the standard number of turns of twist per inch for 39s filling yarn spun from American cotton.

SOLUTION.— $\sqrt{39} = 6.244$. $6.244 \times 3.25 = 20.293$, standard number of turns of twist per in. Ans.

If carded stock is being used, the above result will be increased about 1 or $1\frac{1}{2}$ turns per inch; thus, $20.293 + 1 = 21.293$ turns of twist per inch for carded stock.

DRAFTS

11. Draft calculations for the mule are performed in a manner similar to that employed in the case of the ring spinning frame. The following examples illustrate the methods of finding the total draft, constant for total draft, size of change gear required to produce any desired draft, and the draft produced by a certain size of change gear:

EXAMPLE 1.—Find the total draft, or the draft between the front and back drawing rolls, according to the data given in Fig. 1.

SOLUTION.— $\frac{1 \times 120 \times 56}{19 \times 41 \times 1} = 8.626$, total draft. Ans.

EXAMPLE 2.—Find the constant for the total draft according to the data given in Fig. 1, considering the 41-tooth gear as the draft gear.

SOLUTION.— $\frac{1 \times 120 \times 56}{19 \times 1 \times 1} = 353.684$, constant for total draft. Ans.

EXAMPLE 3.—Find the size of the draft gear required to produce a draft of 8.626 when the constant is 353.684.

SOLUTION.— 353.684 ÷ 8.626 = 41.002, or practically a 41-tooth draft gear. Ans.

EXAMPLE 4.—Find the draft produced by a 41-tooth draft gear when the constant is 353.684.

SOLUTION.— 353.684 ÷ 41 = 8.626, draft. Ans.

PRODUCTION

12. The **production** of mules may be found in three general ways: (1) by taking into consideration the number of stretches per minute, the length of each stretch, the number of spindles per mule, the counts of yarn being spun, and the length of time run; (2) by using indicators, or hank clocks; (3) by keeping an account of the weight of each doff for a given period, adding the estimated amount on the spindles at the end of this time, and deducting the amount on the spindles at the beginning.

13. To find the production for a given length of time according to the first method:

Rule I.—*Divide the product of the number of stretches per minute, the length of each stretch, 60 (the number of minutes per hour), the number of hours run, the number of spindles per mule, and the number of mules by the product of 36 (the number of inches in a yard), 840 (the number of yards in a hank), and the counts of the yarn being spun. Usually a deduction of about 10 per cent. is made for stoppages, such as doffing, cleaning, etc.*

EXAMPLE 1.—Find the total number of pounds produced in a week of 60 hours, making a deduction of 10 per cent. for stoppages, etc., by 6 mules of 780 spindles each. The yarn being spun is 39s and each mule makes $5\frac{1}{4}$ draws, or stretches, of 62 inches, per minute.

SOLUTION.— $\frac{5\frac{1}{4} \times 62 \times 60 \times 60 \times 780 \times 6}{36 \times 840 \times 39} = 4{,}871.428$ lb. 10 per cent. of 4,871.428 = 487.142. 4,871.428 − 487.142 = 4,384.286 lb. Ans.

To find the production for a given length of time according to the second method, that is, using indicators:

Rule II.—*Multiply the number of hanks per spindle produced by each mule by the number of spindles in that mule and divide by the counts of yarn being spun on that mule, to find the number of pounds produced. To find the total number of pounds produced, add the number of pounds produced by each mule. Usually a deduction of from 2½ per cent. upwards is made for waste, etc., although in some cases the indicators are constructed so as to provide for this allowance.*

EXAMPLE 2.—Find the total number of pounds produced by 6 mules of 780 spindles each, making a deduction of 3½ per cent. for waste, etc. The hank clock on each mule registers, respectively, 38.25, 37.5, 37, 37.25, 38.75, and 38.5 hanks, while the counts of the yarn being spun are 39s.

SOLUTION.—

$$\frac{38.25 \times 780}{39} = 765 \text{ lb.}$$

$$\frac{37.5 \times 780}{39} = 750 \text{ lb.}$$

$$\frac{37 \times 780}{39} = 740 \text{ lb.}$$

$$\frac{37.25 \times 780}{39} = 745 \text{ lb.}$$

$$\frac{38.75 \times 780}{39} = 775 \text{ lb.}$$

$$\frac{38.5 \times 780}{39} = 770 \text{ lb.}$$

765 + 750 + 740 + 745 + 775 + 770 = 4,545 lb. 3½ per cent. of 4,545 = 159.075. 4,545 − 159.075 = 4,385.925 lb. of 39s yarn. Ans.

The solution of the previous example can be simplified somewhat, as there are the same number of spindles in each mule and the same counts of yarn being spun, although when the number of spindles and counts of yarn differ this cannot be done.

Rule III.—*Multiply the sum of the hanks per spindle produced by each mule by the number of spindles per mule and divide by the counts of the yarn. The usual deduction for waste should be made.*

EXAMPLE 3.—Same as example 2.

SOLUTION.— 38.25 + 37.5 + 37 + 37.25 + 38.75 + 38.5 = 227.25, total number of hanks. $\frac{227.25 \times 780}{39}$ = 4,545 lb. 3½ per cent. of

4,545 = 159.075. 4,545 − 159.075 = 4,385.925, total number of lb. of 39s yarn. Ans.

To find the production for a given length of time according to the third method:

Rule IV.—*Find the total number of pounds doffed for the given time, add to this the estimated number of pounds on the spindles at the end of this time, and then deduct the number of pounds on the spindles at the commencement of this time.*

EXAMPLE 4.—Find the total number of pounds of yarn produced in 1 week by 6 mules that have produced 121 doffs of practically 36 pounds each. At the end of the week there is approximately 100 pounds of yarn on the spindles, while at the end of the previous week, or the beginning of the week under consideration, there was 71 pounds.

SOLUTION.— 36 × 121 = 4,356 lb. doffed. 4,356 + 100 = 4,456. 4,456 − 71 = 4,385 lb. produced. Ans.

14. Average Counts.—It is frequently necessary to ascertain the average counts of yarn being spun by a number of mules which are producing yarns of various counts. This may be accomplished as illustrated by the following example:

EXAMPLE.—Find the average counts of yarn being spun in a mule room if the mules produce 5,834.40 pounds of 20s, 5,335.20 pounds of 30s, 2,026.44 pounds of 39s, 1,082.64 pounds of 44s, and 1,837.68 pounds of 50s per week.

SOLUTION.—

5834.40	× 20 =	116688.00
5335.20	× 30 =	160056.00
2026.44	× 39 =	79031.16
1082.64	× 44 =	47636.16
1837.68	× 50 =	91884.00
16116.36		495295.32

495,295.32 ÷ 16,116.36 = 30.732s, average counts. Ans.

15. To find the number of yards in a cop of any counts of yarn when the counts of the yarn and the weight of the cop are known:

Rule I.—*Divide the product of the weight of the cop, in grains, 840 (the number of yards in 1 hank), and the counts of the yarn by 7,000 (the number of grains in 1 pound).*

EXAMPLE 1.—Find the number of yards in a 330-grain cop of 39s yarn.

SOLUTION.— $\frac{330 \times 840 \times 39}{7{,}000} = 1{,}544.4$ yd. **Ans.**

To find the number of stretches, or draws, in a cop of any counts of yarn when the weight of the cop, the counts of the yarn, and the length of the stretch are known:

Rule II.—*Divide the product of the weight of the cop, in grains, 840 (the number of yards in 1 hank), 36 (the number of inches in 1 yard), and the counts of the yarn by the product of 7,000 (the number of grains in 1 pound) and the number of inches in one stretch.*

EXAMPLE 2.—Find the number of 62-inch stretches required to produce a 330-grain cop of 39s yarn.

SOLUTION.—

$$\frac{330 \times 840 \times 36 \times 39}{7{,}000 \times 62} = 896.748 \text{ stretches.}$$ **Ans.**

CHANGING THE COUNTS

16. Draft Gear.—To find the size of the draft gear required to produce a yarn of certain counts when the counts of the yarn being spun and the draft gear in use are known and when the hank of the back roving remains the same:

Rule I.—*Multiply the counts of the yarn being spun by the draft gear in use and divide by the counts of the yarn desired.*

EXAMPLE 1.—Find the size of the draft gear required to produce 45s yarn when 39s is being spun with a 41-tooth draft gear. The hank of the back roving is the same in both cases.

SOLUTION.— $\frac{39 \times 41}{45} = 35.533$, or practically a 36-tooth draft gear. **Ans.**

To find the size of the draft gear required to produce a yarn of certain counts when the hank of the back roving is to be changed, and the counts of the yarn being spun, the draft gear in use, the hank of the back roving being used, and the hank of the back roving to be used are known:

Rule II.—*Divide the product of the counts of the yarn being spun, the gear being used, and the hank of the back roving to be*

used by the product of the counts of the yarn required and the hank of the back roving being used.

EXAMPLE 2.—Find the size of the draft gear required to produce 45s yarn with a 6-hank back roving when 39s is being spun from 4.5-hank back roving with a 41-tooth draft gear. The back roving is running single; that is, one end per spindle.

SOLUTION.— $\frac{39 \times 41 \times 6}{45 \times 4.5} = 47.377$, or practically a 47-tooth draft gear. Ans.

17. Twist, or Speed, Gear.—To find the size of the speed gear required to give the proper twist for any counts of yarn without changing the rim pulley, when the counts of the yarn being spun, the counts of the yarn to be spun, and the size of the speed gear being used are known:

Rule.—*Multiply the size of the speed gear being used by the square root of the counts required and divide by the square root of the counts being spun.*

EXAMPLE.—Find the size of the speed gear required for 45s yarn when 39s is being spun with a 66-tooth speed gear.

SOLUTION.— $\sqrt{39} = 6.244$; $\sqrt{45} = 6.708$. $\frac{66 \times 6.708}{6.244} = 70.904$, or practically a 71-tooth speed gear. Ans.

18. Rim Pulley.—To find the size, or diameter, of the rim pulley required to give the proper twist for any counts of yarn without changing the speed gear, when the counts of the yarn being spun, the counts of the yarn to be spun, and the diameter of the rim pulley being used are known:

Rule.—*Multiply the diameter of the rim pulley being used by the square root of the counts required and divide by the square root of the counts being spun.*

EXAMPLE.—Find the diameter of the rim pulley required for 45s yarn when 39s is being spun with a 16-inch rim pulley.

SOLUTION.— $\sqrt{39} = 6.244$; $\sqrt{45} = 6.708$. $\frac{16 \times 6.708}{6.244} = 17.188$, or practically a 17-inch rim pulley. Ans.

19. Builder Gear.—To find the size of the builder gear to give the required rate of movement to the builder for any counts of yarn, when the counts of the yarn being

spun, the size of the builder gear being used, and the counts of the yarn required are known:

Rule I.—*Multiply the builder gear being used by the square root of the counts of the yarn required and divide by the square root of the counts of the yarn being spun.*

EXAMPLE 1.—Find the size of the builder gear required to spin 45s yarn when 39s yarn is being spun with a 28-tooth builder gear.

SOLUTION.— $\sqrt{45} = 6.708$; $\sqrt{39} = 6.244$. $\frac{28 \times 6.708}{6.244} = 30.08$, or practically a 30-tooth builder gear. Ans.

Rule II.—*Multiply the square of the builder gear being used by the counts of yarn that it is desired to spin and divide by the counts of yarn being spun. Extract the square root of the result thus obtained.*

EXAMPLE 2.—Same as example 1.

SOLUTION.— $\frac{28^2 \times 45}{39} = 904.615$. $\sqrt{904.615} = 30.077$, or practically a 30-tooth builder gear. Ans.

Another method of finding the size of the builder gear for any counts of yarn requires that the constant for the builder gear shall first be found.

To find the constant for the builder change gear when the length of the screw being used and the pitch, or number of threads to the inch, in the screw are known:

Rule III.—*Multiply the length, in inches, of the part of the screw that is being used by the pitch of the screw.*

EXAMPLE 3.—Find the constant for the builder change gear when $7\frac{1}{2}$ inches of a 4-pitch screw is being used during the formation of a set of cops.

SOLUTION.— $7.5 \times 4 = 30$, constant. Ans.

To find the size of the builder change gear required for any counts of yarn when the constant for the change gear, the weight of a full cop of yarn, the length of one stretch, and the counts of the yarn required are known:

Rule IV.—*First find the number of stretches required for a full cop of yarn of the weight and counts required, and then divide the number of stretches required by the constant.*

EXAMPLE 4.—Find the size of the builder gear required for a 62-inch stretch mule to spin a 330-grain cop of 45s yarn when the constant for the builder change gear is 30.

SOLUTION.— $\frac{330 \times 840 \times 36 \times 45}{7{,}000 \times 62}$ = 1,034.709 stretches. 1,034.709 ÷ 30 = 34.49, or practically a 34-tooth builder gear. Ans.

NOTE.—It will be seen that the result obtained by Rules III and IV varies somewhat from the results obtained by Rules I and II. Since, however, the proper size of builder gear is influenced by many other factors, such as the tension on the yarn during winding (which is governed by the amount of weight on the counter faller and the action of the quadrant), the amount of twist inserted in the yarn, etc., no rule will give absolutely accurate results. Rules for finding the size of the builder gear must therefore be considered as giving approximate results only, and it may often be found necessary to slightly increase or decrease the calculated size of the builder gear as the case may require.

TYPES, ARRANGEMENT, AND DIMENSIONS

20. All cotton mules can be divided into two principal types—**cam-shaft mules** and **long-lever mules**. Advantages are claimed for both classes, but cam-shaft mules are more largely used. In general arrangement these two types of mules are similar; they differ, however, in the construction of the headstock. All makes of mules of either class are practically the same in principle and general construction, differing only in the smaller details, motions, etc.

These classes of mules may each be divided into two subclasses—those having the rim pulley at the back and those having the rim pulley at the side. The mules are built in this manner so that they will be suitable for the room and position in which they are to be placed. In a mule with the rim pulley at the back, the main driving shaft of the machine is at right angles to the rolls and carriage; while in a mule with the rim pulley at the side, the shaft runs parallel with the rolls and carriage.

21. One especially noticeable feature in which mules are different from most cotton-yarn preparation machines is in their relation one to the other as regards arrangement. They are usually arranged in pairs, with the carriages facing each other, as shown in the plan view in Fig. 2.

The headstocks *a* are not located directly in the center, but are placed at one side, as shown, so that they may overlap; this saves considerable floor space, since only sufficient space is left between the headstock of one mule and the carriage of the other to allow the *minder*, *tender*, or *mule spinner*, as he is frequently called, to pass when the carriage is in its extreme outward position. This arrangement brings the long section of one carriage opposite the short section of the other and aids the mule spinner in the performance of his duties in attending to the running of the mules. The creels, roll beams, and carriages are shown at *b*, c_4, and *d*, respectively.

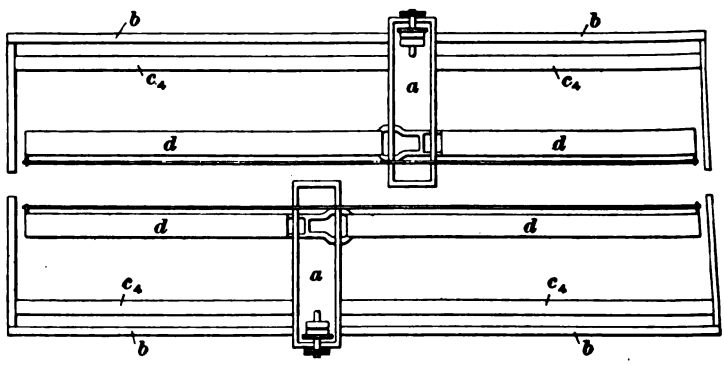


FIG. 2

The arrangement of the mules in the room depends mainly on the direction in which the shafting of the room runs, the size of the room, type of mule to be used, the total number of spindles required, the length of the mules, etc. When the shafting runs lengthwise of the room and the mules have the rim pulley at the side, they usually extend lengthwise of the room, while on the other hand, if the rim pulley is at the back, they extend crosswise. When the shafting runs crosswise and the mules have the rim pulley at the side, they extend crosswise, and lengthwise when the rim pulley is at the back.

22. The dimensions vary with the make of the mule, the number of spindles, the gauge of the spindles, the position

of the rim pulley (whether at the back or at the side), the length of the stretch, etc. The mule under consideration is for spinning medium counts and contains 780 spindles, $1\frac{1}{4}$-inch gauge. It occupies a floor space 87 feet long and 11 feet wide, while a pair of mules of the same size, arranged as shown in Fig. 2, occupy a floor space 87 feet long and 19 feet 6 inches wide.

A $4\frac{1}{2}$-inch double belt is used to drive the rim shaft, while Table I gives the diameter of the various bands.

TABLE I

Bands	Diameter Inch
Rim	$\frac{1}{2}$
Taking-in friction	$\frac{1}{2}$
Drawing-out	$\frac{1}{2}$
Drawing-in	$\frac{7}{8}$
Checking	$\frac{7}{8}$
Quadrant	$\frac{7}{8}$
Rewinding	$\frac{1}{2}$
Scroll and back shaft, or steadying	$\frac{7}{8}$
Cop-bottom governing motion	$\frac{3}{8}$
Squaring	$\frac{3}{8}$
Spindle	$\frac{3}{32}$

23. The horsepower required to drive a mule varies, especially during the different periods in its actions. It is generally estimated, however, to be about 1 horsepower for every 100 to 110 spindles for coarse counts, 110 to 120 for medium counts, and 120 to 130 for fine counts. Generally speaking, a mule of about 700 spindles, spinning medium counts, with a spindle speed of about 9,000 revolutions per minute, under favorable conditions will require, during the drawing-and-twisting period, about 25 horsepower for the first 2 or 3 seconds as the carriage starts out; after that it decreases to about 10 or 12 horsepower until the carriage

completes its outward run, when the horsepower is reduced to about 1 or 1½ until backing off is completed. As winding commences and the carriage starts in, the power required is increased from 1 or 1½ to about 3 horsepower. This continues until the winding is completed, when the power is decreased to practically nothing. These results were taken from actual tests and show the relative amount of power required during the different periods in the action of the mule; they will not apply to all mules, however, as the power varies considerably.

CARE OF MULES AND MULE ROOM

24. The proper care of the mules and mule room is imperative to the welfare of the mill, as well as the care of any of the previous machines required for the manufacture of cotton yarns. The mules should be properly and thoroughly oiled and cleaned at regular stated intervals. The rolls should be properly cared for, and the top rolls recovered with the best of material as soon as any defects develop. Good rolls are very essential to the production of good, even yarn with little waste and also to a large production, since poor rolls decrease the production by breaking the ends, etc.

The belts and large bands should be cleaned and dressed at regular periods to prevent slippage and excessive wear, and to prolong their life and driving power. The bands should also be stretched before being put on, so as to prevent slippage through the band stretching excessively and becoming slack; this is especially advisable in connection with the rim band. Although there are arrangements for tightening the various bands when they stretch, there is a limit to the amount of slack that can thus be taken up; consequently, it is advisable, and in fact necessary, to have as much of the stretch taken out of the bands as possible before they are put on. The endless bands should be spliced so that they will be very little, if any, larger at the splice than at the regular diameter; the splice should also be fairly long, so that any slight increase in diameter will be gradual and so that the splice will not give while the bands are under tension.

All parts should be properly set and adjusted to act at the proper time for the counts of yarn being spun. Care should also be taken not to have an excessive or insufficient amount of tension, twist, roll delivery, ratch, or gain. The spindle and roll speeds should not be too high, as this would be a detriment to the production of first-quality yarn. The clutches and cone frictions should be carefully adjusted and cared for. Especial care should be given to the leather coverings on the faces of the cones of the frictions to secure proper driving of the various parts.

CAUSES AND REMEDIES FOR DEFECTIVE YARN AND COPS

25. There are many causes for defective yarn and cops, thus making it very difficult at times, especially on such a complicated machine as the mule, to find the direct cause in any special instance, as there are a number of conditions, and in some cases a combination of conditions, that may produce a particular defect. To find the cause of the defect is usually the most difficult part, although in many cases it requires considerable skill and judgment to remedy it, especially if the mule is an old one or has not received proper care and adjustment.

26. Uneven Yarn.—The use of long- and short-staple cotton together is frequently the cause of **uneven yarn**; as the fibers do not draw properly because the rolls cannot be set to accommodate cotton, the staple of which differs greatly; this can be remedied only by using cotton of a more even length. When uneven back roving is the cause of this defect, the fault must be corrected in the picking and carding department, if it does not lie in the use of cotton of uneven length of staple. If there is too much twist in the roving, thus preventing its drawing properly, the amount of twist must be reduced until there is only sufficient to allow the roving to unwind from the bobbins without stretching and breaking. If the roving does not unwind properly from the bobbins, on account of their motion being retarded, it should be ascertained if the skewers are properly pointed at

the lower ends, the steps or bearings clean and in good condition, the upper ends of the skewers free from waste, etc., and that one bobbin does not rub against another. All that is necessary when excessive or incorrectly proportioned drafts are the cause of uneven yarn, is to properly adjust the draft, either by reducing the total draft or by altering the individual drafts so that the front one will not be too great in proportion to the rear one, or vice versa. For insufficient weighting of the rolls, the amount of weight should be increased sufficiently to cause the rolls to properly grip and hold the fibers, but the amount of weight should not be excessive. Rolls should be so set that the distance between their centers will only slightly exceed the average length of the fibers; poorly covered rolls should be replaced with good ones and the others re-covered. When top rolls become grooved they should be replaced by good rolls; if bottom rolls are badly grooved they should be repaired immediately if possible, but if this cannot be done, they should be replaced with good ones, and the others sent away to be refluted. Bottom rolls that have worn smooth should be also refluted or replaced by good ones. If the carriage is out of true, it should be alined parallel with the drawing rolls, and the bands so adjusted that it will be parallel at all times throughout its outward and inward runs.

27. Cut Yarn.—When cut yarn is caused by excessive drafts with wide setting of the rolls, this defect can be overcome by reducing the draft and setting the rolls properly. For irregular movement of one or more of the bottom rolls, caused by a gear slipping, a new key should be put in the roll shaft, sleeve, or stud, as the case may be, to prevent the gear slipping; or if the key is all right, the fault may be due to a nut being loose. Gears with broken teeth should be repaired or replaced with perfect ones to avoid lost motion. When a roll is loose at the connections, either the entire roll or a portion that will include the loose connections should be removed and the connections tightened so that they will be perfectly firm; if the neck is broken, either the entire roll

or the portion containing the break should be taken out and repaired. To overcome too much backlash, or play, in the roll gears, the gears should be set so as to mesh more deeply, unless the teeth are worn considerably, when new gears should be used. When cut yarn is caused by the rolls being out of true, poorly covered, or insufficiently weighted, or by the top rolls being out of line, the remedy is obvious.

Sometimes cut yarn is the result of the winding faller unlocking too late, since there will not be enough yarn left to form the open spirals on the blades of the spindles; this can be avoided by the proper adjustment of the bracket for unlocking the faller; or the counter faller may be too heavily weighted, thereby producing excessive tension on the yarn. The carriage may strike in too hard, thus causing it to rebound, because the belt is too tight, in which case one that is a little longer should be used; the keenness of the hastening motion may need to be reduced, or the checking band may need to be tightened. When the carriage strikes out too hard, the belt should be shipped earlier if it remains on the tight pulley for too great a time; or if the drawing-in bands are too slack, they should be tightened.

28. Cockled, or Curled, Yarn.—The use of long- and short-staple cotton together is sometimes the cause of **cockled, or curled, yarn**, since it does not draw properly. In some cases, the back roving has too much twist to allow the yarn to draw properly. To prevent the rolls becoming dry and sticking, they should be oiled properly and at regular intervals; and if they are clogged with waste or gummy oil it should be removed because the motion of the rolls will be irregular, thus conducing to improper drawing. Cockled yarn is sometimes caused by the rolls being set too close and damaging the fibers; by the top rolls not being weighted properly, causing slippage; and by faulty adjustment of the saddles. Sometimes the roll covers become loose, necessitating the use of newly covered rolls.

29. Kinky Yarn.—If the spindles are inclined too much toward the rolls for the counts being spun, **kinky yarn**

is liable to result; this, of course, may be remedied by changing the angle of the spindles so that it will be more acute, thereby preventing the yarn slipping off the ends of the spindles too easily. When an extra amount of twist is inserted with insufficient tension, the tension should be increased. If the carriage runs out too slowly, its speed should be increased sufficiently to prevent kinking. The bracket for unlocking the faller may need adjusting if the faller is unlocking too early at the end of the inward run. It may be necessary to increase the amount of tension on the yarn during backing-off by having the fallers weighted a little more heavily during this period; or perhaps the backing-off chain may need adjusting so that the fallers will come into their winding position more quickly. In some cases the rim band or spindle bands may need to be tightened, while in other cases the cylinder may be slipping and require adjustment.

30. Overstrained Yarn.—If the counter faller is set too low, it may snap up during backing-off and strain the yarn. Sometimes the winding faller descends too rapidly during backing-off, thus producing excessive tension on the yarn, in which case the backing-off chain must be adjusted so that the faller will lower more slowly; sometimes the counter faller is too heavily weighted. If the quadrant is set too far forwards, that is, too near the front of the headstock, it sometimes causes the yarn to be strained as the carriage starts on its inward run, because the speed of the spindles will be excessive; if set too near the rear of the headstock, it sometimes causes strain on the yarn when the carriage has almost completed its inward run, because more than the required amount of chain will be unwound from the winding drum, thereby causing the spindles to rotate too rapidly. If overstrained yarn is caused by the carriage being out of true, it should be alined and the bands adjusted.

31. Dirty Yarn.—Dirty back roving will result in dirty yarn and for that reason care should be taken that the roving is clean when it comes from the carding department. Dirty

creels, dirty traverse guides, dirty rolls, and dirty clearers will also cause dirty yarn; all these parts should be cleaned regularly. This defect may be the result of too copious or too frequent oiling of the spindles and other parts, causing the oil to rise and be thrown off on to the yarn, etc. If the ceiling and hangers are cleaned while the mules are in operation, the dirt is liable to fall on the yarn or on the back roving and be carried forwards and incorporated with the yarn. Fanning or blowing the dirt when cleaning the roll beam, or when sweeping and cleaning up the floor, will also cause dirty yarn.

32. Defective Cop Bottoms.—If the base of the cop bottom is too long, it can be shortened by lowering the shoulder, or highest portion, of the builder rail; in some cases this is done by adjusting the builder shoes, while in others the upper portion of the front and back shoes, or the portion used during the formation of the cop bottoms, must be filed so that the starting point of both the front and back studs of the builder rail will be lower, while the finishing points remain unchanged.

If the base of the cop bottom is too short, it can be lengthened by raising the shoulder of the builder rail; this can be accomplished in some cases by adjusting the builder shoes, while in others the upper portion of the front and back shoes must be filed so that the starting point of both the front and back studs will remain unchanged, while the finishing point will be lowered. The filing of the builder shoes or builder rail is a very difficult operation, since it is essential that exact accuracy be obtained, and should never be attempted except in rare cases, and even then only when no other remedy is possible.

33. Incorrect Chase.—If the chase of the cop is too long, it can be shortened by lowering the front end of the rail, by turning the adjusting screw at the front in the required direction. This decreases the height of the shoulder of the builder rail so that the winding faller will not be depressed

If the chase of the cop is too short, it can be lengthened by allowing the winding faller to be depressed more, by increasing the height of the front end of the rail; this is accomplished by turning the adjusting screw at the front end of the rail in the required direction and increases the incline of the long portion of the builder rail.

In some makes of mules, the adjusting screw for altering the difference in height between the two ends of the builder rail is situated at the rear instead of at the front. When this is the case, the inner end of the rail must be raised to shorten the chase and lowered to lengthen it.

34. Soft Cops.—If the cops are too soft, this may be the result of the counter faller being insufficiently weighted. If the spindles do not revolve fast enough during winding, the action of the nosing peg should be made more keen; that is, the peg should be made to depress the winding chain to a greater extent, or the quadrant screw should be turned so as to lower the traveler, or nut, slightly. It may be necessary to tighten the backing-off chain. Sometimes the chase of the cop must be increased in length. Occasionally the shoulder of the builder rail becomes so worn as to be almost flat, causing the cops to be too large in diameter, in addition to being soft; in this event, the shoulder should be repointed. Soft cops are caused in some cases by slack rim bands, slack or oily spindle bands, and by the cylinders being loose or slipping; the remedy in these cases is obvious.

35. Ridgy cops may be caused by the bowl that slides on the builder rail being so worn as to have an irregular outline; this can be remedied by using a new bowl or by having the old one turned down so as to be regular. If the hole in the center of the bowl or the stud on which the bowl is mounted, is worn, a new bowl or stud should be used or the old ones repaired so as to work properly. Sometimes the bowl requires adjusting so that the whole width of its face will rest on the rail. The bowl on which the boot leg rests may be so badly worn that a new one is necessary; or it may be possible to repair the old one, as in the case of

the bowl that slides on the builder rail. If the threads of the builder screw have become worn, a new screw will be needed, as will also be the case if the threads are burred or otherwise accidentally damaged, unless the screw can be easily and properly repaired. The builder screw may be so bent that the nut that works on the screw will bind, in which case it will only be necessary to straighten the screw so that the nut will work easily. Sometimes the builder-screw threads and nut are so clogged with hardened oil or waste that the nut cannot move freely; a new builder-screw nut may be needed to replace one that is worn excessively or damaged. If the surface of the builder shoes is worn irregular, it will be necessary to either use new shoes or file the old ones carefully so as to produce a regular surface. The winding faller may not work smoothly on account of binding in some of the bearings, due to the shaft being bent or out of line or the bearing being clogged, too small, or out of true; sometimes some of the winding-faller bearings are worn to such an extent that the shaft does not work properly, in which case it will be necessary to either repair the worn bearings or use new ones. All of these defects tend to irregularity in the movement of the winding faller.

36. Locking of Winding Faller.—To alter the locking of the winding faller, the shoe for the loose incline is moved so as to change its relation to the front shoe of the long rail. Moving the shoe backwards increases the angle of the loose incline and thus allows the faller to lock later, while moving the shoe forwards produces the opposite effect.

37. Adjustment of Catch.—To get the mule on the catch better, it is sometimes necessary to reduce the keenness of the belt-shipping mechanism, so that the carriage will have sufficient momentum to carry it outwards the full length of its stretch. At other times it is necessary to have less of the small diameters of the back-shaft scrolls operating on the bands, so that the carriage will be drawn out to the stops properly; while at still other times it is necessary to adjust

the front stops because they are out of line or not set forwards sufficiently to allow the carriage to be locked.

If the carriage does not run out sufficiently to be locked properly, the mule is liable not to back off, as the backing-off cone friction cannot be properly thrown in, while in some cases the winding catch may be thrown in earlier than required.

38. Slipping of Winding and Backing-Off Catches. If the gears or pawls are worn, or if they slip, the winding and backing-off catches are liable to slip. This is also liable to happen if the pawls are not set properly; if the springs are too weak or are not bent correctly; or if the leather friction pad is worn, or is soaked too much with oil, thus causing it to loose its grip.

39. The various defects with their remedies that have been mentioned are the more common ones, but there are many other defects that are occasionally met with. Those given, however, will serve to show the complexity of the mule and the numerous points that must be constantly taken into consideration.

SPECIAL MOTIONS

40. When spinning fine counts, and sometimes medium counts, special motions or motions other than those described in direct connection with the mule are used, in order to produce a higher-grade and a more even yarn.

41. Twisting at the head is sometimes advisable when spinning very fine counts. This allows the yarn to receive more twist than otherwise, as the spindles revolve for a short length of time after the carriage has completed its outward run before backing off is allowed to take place. A definite amount of twist can thus be inserted when it is not deemed advisable to insert it all during the outward run of the carriage.

42. Dwell, or antisnarling, motions are applied to prevent snarls or kinks forming in the yarn when the carriage

is at, or near, the beam; the rolls remain inactive for a very brief period just as the carriage starts outwards, thus allowing the yarn to be brought under a slight tension. This motion is usually automatic and adjusts itself so as to be more keen, or active, as the cops increase in size, although some very efficient ones that have to be set by hand as the cops increase in size are frequently applied.

43. Roll-Delivery Motions.—There are two **roll-delivery motions**; one acts during twisting at the head and the other during winding. The object of the first is to relieve the excessive strain on the yarn that would be caused by its contracting in length, due to the extra amount of twist. The object of the second one is to relieve the yarn of any excessive strain caused during winding, and also to increase the production. During the action of both of these motions the rolls are caused to revolve very slowly, so as to deliver a few, usually about two or three, inches of yarn. The exact amount delivered depends on the counts of the yarn, the amount of twist inserted, etc.

44. The **jacking motion** is applied in some cases to stop the rolls a short time before the carriage completes its outward run, thus allowing the yarn that has been delivered and twisted to be stretched, or *ratched*, as it is frequently termed. This ratch causes the yarn to be more even, as the major part of the twist runs to the thin places, thus allowing the thick, uneven places that have comparatively little twist to be drawn to a uniform size, so that the yarn is comparatively even, both in diameter and twist, throughout its length. This aids greatly in the production of fine, even yarns. The amount of ratch depends on the counts of the yarn, the quality of the stock, the amount of twist inserted, the length of the stretch of the mule, etc., but it seldom exceeds 3 or 4 inches.

45. Gain.—The expression **gain** refers to the excess speed of the carriage over the surface speed of the front drawing roll for any one stretch. The amount of gain, or increase, in this case, as well as the ratch in the previous

case, depends on the counts of the yarn being spun, etc. In the case of a 62-inch-stretch mule, the rolls might deliver only 60 inches of yarn while the carriage was moving outwards for 62 inches, thus making a gain of 2 inches. This has a tendency to even the yarn after the order of the jacking motion.

TWISTERS

INTRODUCTION

1. For many purposes, yarns are desired that have a greater strength and a greater resistance to friction than is found in single yarns. Since a single yarn consists of only one strand of fibers, it is liable to be pulled apart if subjected to any process that frays its surface, or in which a strain is brought on the yarn beyond what it can be expected to sustain; when, however, two or more single threads are placed together and twisted in the opposite direction to that in which they are spun, thus forming what is called a **ply yarn**, the tendency to fray is largely reduced, because each thread resists the tendency toward the separation of the fibers in the other thread, or threads. A ply yarn composed of two or more single yarns has considerably more strength than one single yarn of the same weight as the ply yarn; that is, by making a ply yarn a greater strength is obtained from the same weight of material. Another object in making ply yarns is to introduce ornament by the use of colored threads, making what are known as *twists*, or *grandrelles;* this, however, is not of so much importance as the first object. Ply yarns are used:

1. In weaving for warp, filling, and extra threads. They are chiefly used for warp, but in some cases, where an exceedingly strong fabric is required, the filling is also ply yarn. The reason for using ply yarn for warp is that warp yarn has to stand a greater strain than filling yarn during weaving, as well as the chafing of the harnesses and reed. This is more severe on the ends at each side of the cloth, known as selvage

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ends, since they have also to withstand a lateral pull toward the center of the cloth. Cotton fabrics are not often made with ply yarn for the entire warp, but frequently with single yarn in the body of the cloth and ply yarn for the selvages. For ornamental borders, and in some fabrics where extra threads are introduced, such as figured cloth, or where individual threads have an unusual strain brought on them in the weaving process, as in leno fabrics, ply yarns are used.

2. In the knitting industry, where a special appearance or feel is desired in the knitted fabric that can only be obtained by using yarns with two or more threads twisted together, or where the extra threads are used in such parts of the fabric as heels of socks, where unusual wear occurs, and where a ply yarn is therefore desirable.

3. For lace making, curtain manufacturing, embroidery, etc., in which it is essential to have a fine, even yarn of considerable strength.

4. For sewing threads, crochet threads, mending yarns, machine twists, seaming, covering, and other yarns, in which, as they have to pass through the eye of a needle, either in a manual or power process, evenness and strength are very desirable qualities.

5. For twine, string, and cord.

6. For novelty yarns.

2. The name ply yarns is given indiscriminately to all threads that are composed of two, three, or more strands twisted together at one operation, and they are distinguished from one another by the terms two-ply, three-ply, and so on, which are applied according to the number of strands forming the ply yarn. Single yarns are usually referred to by that name, but are sometimes spoken of as *one-ply*. In Europe, ply yarns are more frequently spoken of as *folded yarns*, and the terms two-fold, three-fold, four-fold, etc. correspond, respectively, to the names two-ply, three-ply, four-ply, etc.

When two or more ply threads are twisted into a thread, they are spoken of as *cabled yarns*. In the sewing-thread trade, the word cord is used instead of ply; thus, six-cord

means a thread with six ends of single yarns, made into a thread by two operations, and is thus a cabled yarn; nine-cord contains nine single ends.

Each operation of twisting is sometimes spoken of as a *throw*; thus, if two ends of 60s are made into a ply yarn it is done at one throw; three ends of this ply yarn may then be made into cabled yarn by another operation, or throw, thus producing 60s six-cord by two throws. Unless otherwise specified, the statements in this Section refer to ordinary ply yarns made by one operation of twisting. Except in special cases, the direction in which the twist is inserted into a ply yarn is opposite to that in each of the single threads of which it is composed.

PROCESSES BEFORE TWISTING

3. The simplest method of making a ply yarn is to take two or more single yarns in the form in which they leave the spinning machine and double and twist them into a ply yarn in one process, on a machine known as a *twister*. This is the usual method of making ply yarns in coarse and medium numbers, where it is not essential to have exceedingly high-grade work; there are disadvantages in this single process, however: (1) Owing to the fact that the single yarn is in the form of a cop or on a spinning bobbin, it is in short lengths, necessitating frequent replacement of bobbins or cops and piecing of ends at the twister. (2) Since the cop or bobbin constantly diminishes in diameter as the yarn is unwound, the tendency is to have the yarn delivered to the twister at varying tensions, making it difficult to obtain an evenly twisted ply thread, and producing a faulty yarn known as *corkscrewed yarn*. (3) As the yarn has not passed through a winding process under tension, where it would have broken at weak or bad places, such breakage occurs at the twisting process. (4) In case one end breaks when making a 2-ply yarn, the other thread will untwist and also break, or in the case of a 3-ply or more, the tendency will be to allow the yarn to pass forwards with one end less

than the required number of strands. (5) When the ply end breaks, it must be repaired by making a bunch knot; that is, tying together ends that each contain two or more single ends, while at a winding process only two single ends would be tied together, thus making a smaller knot.

For all good qualities of ply yarns, it is now customary either to first spool the single yarn from the form in which it leaves the spinning machine, or to wind two or more ends side by side in the form of a spool or parallel tube at a spooling or doubler-winding machine. By first spooling the yarn, or by winding two or more threads together at a doubler-winding machine provided with a stop-motion, so as to stop the winding in case one of the single threads breaks or runs out, the yarn is put up in a much more satisfactory form to twist from, since there is a very much greater length than in any form of single-spun yarn as it leaves the spinning machine. The thread has passed through a process that eliminates broken ends and ends so weak or uneven that they would have broken at the twisting frame; it also gives a better opportunity of attaching broken ends together without the formation of a larger knot than is customary at the twister. The extra expense of this process is compensated for by the better quality of the product and the increased production of the twister. The doubler-winding process is generally used for coarse and medium yarns where a high grade of ply yarn is required, but is not much used for high grades of very fine ply yarns, as for example number 100s and over. In the latter case, the expense of doubler winding would be very great, owing to the small weight produced per day, and as the twisting machines for very fine yarns run slowly, many of the defects that would occur in fast-running twisters for coarse and medium yarns can be avoided.

The necessity for the doubler-winding process is eliminated in some cases by applying to the twister a stop-motion so constructed as to stop the supply of yarn to any one spindle in case of the breakage of a single end, thus eliminating some of the faults that are avoided by the use of a doubler winder.

MACHINES USED BEFORE TWISTING

SPOOLERS

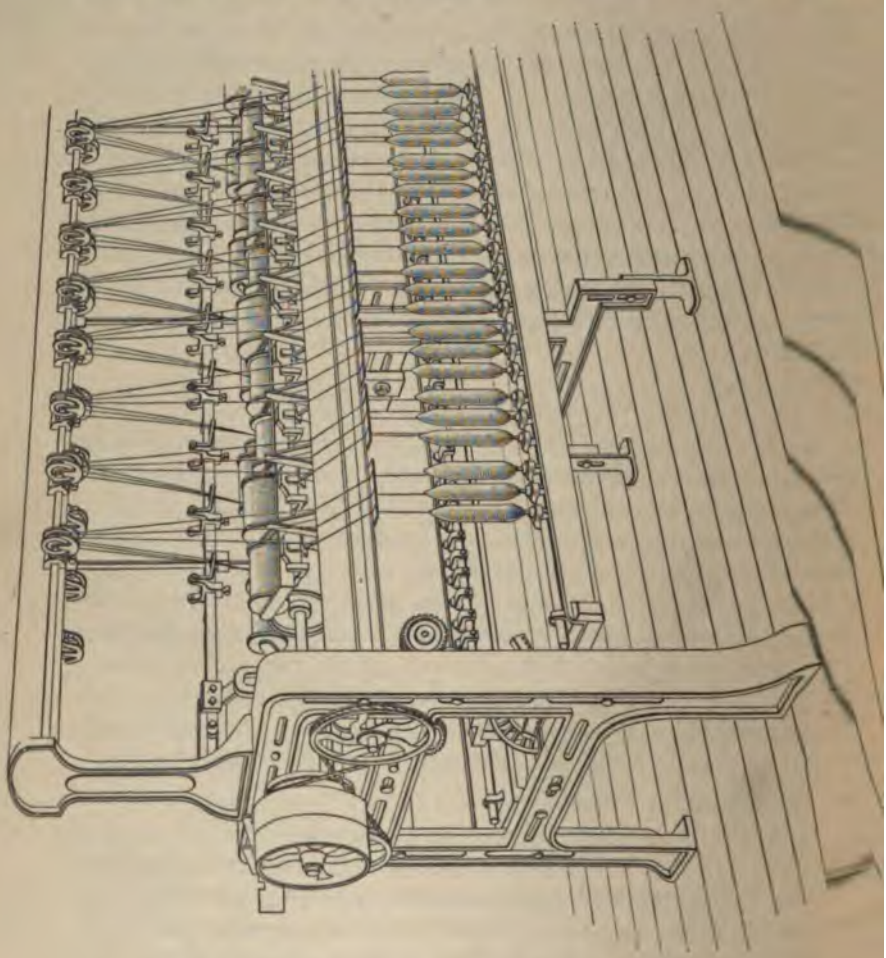
4. In case only one end is required on the spool that is to be placed in the creel of the twister, the simplest manner of obtaining this is to use an ordinary vertical-spindle spooler, which can be arranged to wind from a cop or a ring-spinning bobbin. The yarn is wound on double-headed spools, large spools being used for coarse yarns, and small spools for fine yarns. As the yarn is wound on the spool, it is traversed alternately upwards and downwards from one head to the other, with a speed slightly less near the center than at each end, thus producing a barrel-shaped spool.

DOUBLER-WINDING MACHINES.

5. Where two or more ends are wound together without any twist being imparted, in such a form as is suitable for placing in the creel of the twister, two distinct types of machines are used: (1) the *drum doubler winder* for winding two or more ends from either cops or bobbins on to a double-headed spool, and (2) the *quick-traverse*, or *cross-winding*, *doubler winder*, which winds from cops, ring bobbins, skeins, or spools either on to a paper tube in cylindrical form, known as a *parallel tube*, or *cheese*, or into a cone-shaped form of cheese, known as a *cone*, or *conical tube*. The cone-shaped form, however, is seldom made for twisting purposes.

6. **The doubler drum winder,** one type of which is shown in Fig. 1, consists of a drum shaft, revolving at a constant speed, that receives power directly from a driving shaft of the room, and to which are attached a number of drums; on each side of the machine, in front of each drum, is a swinging frame that supports a wooden spool, on which the yarn is wound. Each frame is independent of the others and holds its spool so that the barrel of the spool presses

lightly against the drum and is revolved by friction. Each drum is just sufficiently long to work between the heads of the spools. At each side of the lower part is placed a creel, which in the illustration is shown constructed to hold cops



that are placed on skewers resting in sockets in the creel. The yarn is taken from the nose of the cop, passed through a suitable guide, over a friction board constructed of wood

covered with flannel, through a guide of a stop-motion, not shown in Fig. 1, and then up and around a pulley near the top of the frame; the two or more ends that are being doubled then pass downwards to and around the wooden spool. In the illustration, yarn is shown on one side of the frame only, three ends passing to each spool. Immediately before passing to the spool, the yarn is passed through a wire guide, there being one guide on each side of the frame for each drum; these guides are attached to traverse rods that guide the yarn slowly from one head of the spool to the other, so that it is built up evenly in layers parallel to the barrel of the spool. Each individual thread passes through a guide of a stop-motion, which is so arranged that when the thread breaks the frame in which that particular spool is carried is thrown from the drum and thus the spool stopped until the end is replaced and connected to the broken part. The machine is constructed similarly on each side, so that each drum serves for two spools, one on each side of the frame.

The creel is so constructed that instead of cops, filling-wind ring-spinning bobbins may be placed on the skewers and the yarn unwound from the nose of the bobbin; or the creel may be changed and replaced with arrangements for holding skeins, double-headed spools, cheeses, cones, taper-wound spools, or any other desired form of yarn. The winding drums are customarily 7 inches in diameter, and for ordinary numbers and qualities of yarn are run at such a speed as will wind about 5,500 inches of yarn on each spool in a minute. The machines are constructed with drums and other parts for spools with either a 4-, 4½-, 5-, or 6-inch traverse between heads, and are made in various lengths from 10 to 90 drums, giving, respectively, 20 to 180 spools per machine. A machine with 30 drums intended for 60 spools, each of 4½-inch traverse, and what is known as a 6½-inch space frame, is 18 feet long.

7. The **quick-traverse**, or **cross-winding, doubler winder** is substantially the same as that used for ordinary tube winding. The simplest form of these machines for

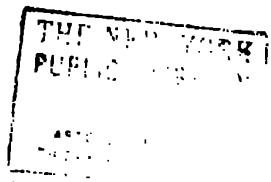
ordinary winding purposes is constructed to wind only one end of yarn on to a paper tube, but when arranged for doubler winding, any number of ends, from two to twenty-four (although not usually more than six) are wound together; these ends lie side by side on a horizontal paper or wooden tube and are gradually built in cylindrical form with a traverse ordinarily not greater than 5 inches, which represents the width of the cheese; the cheese is sometimes constructed with as large a diameter as 6 inches. Occasionally, for special purposes and coarse yarns, these machines are so constructed as to build a cheese as large as 8 inches in diameter, usually with a 6-inch traverse.

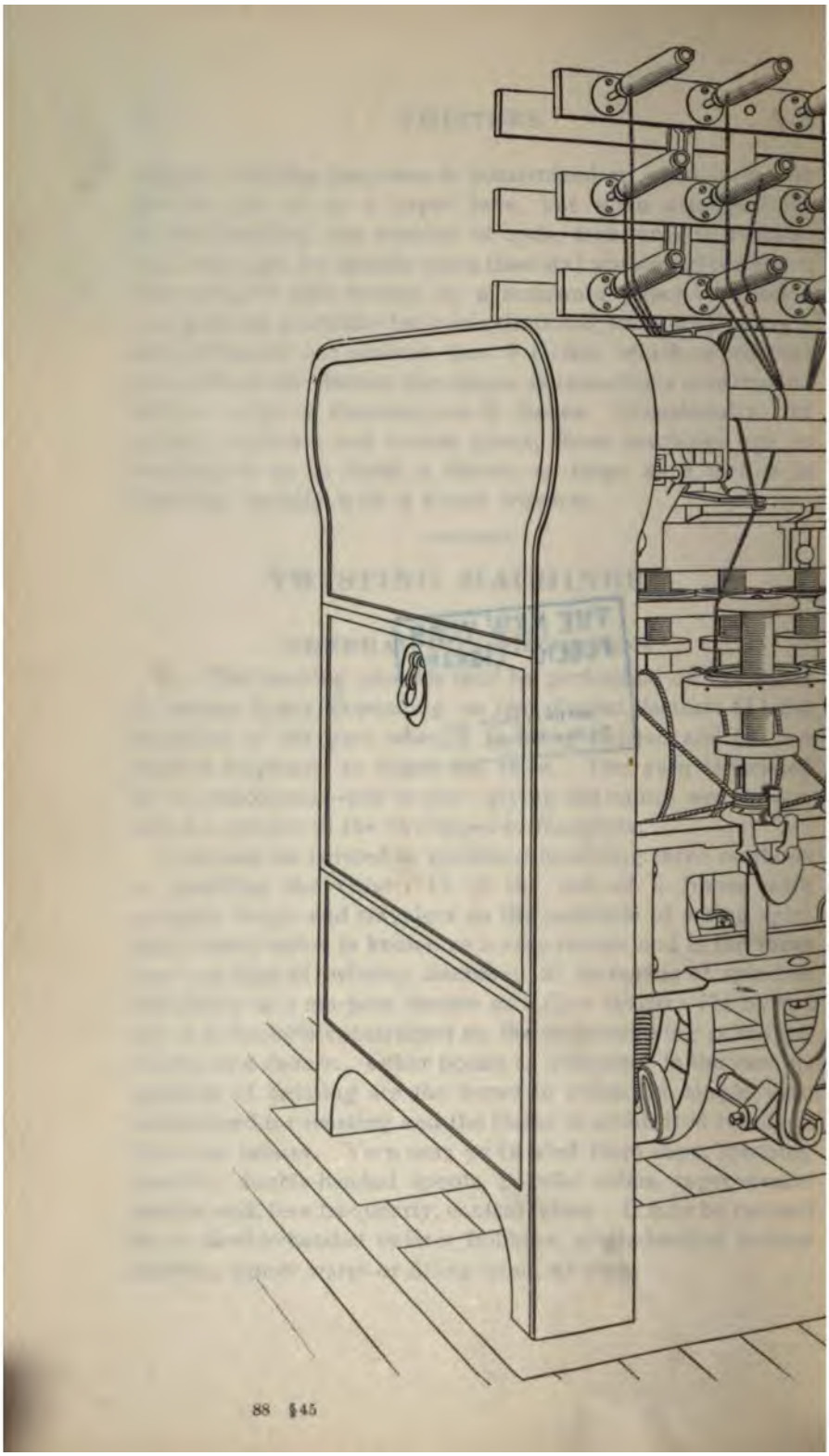
TWISTING MACHINERY

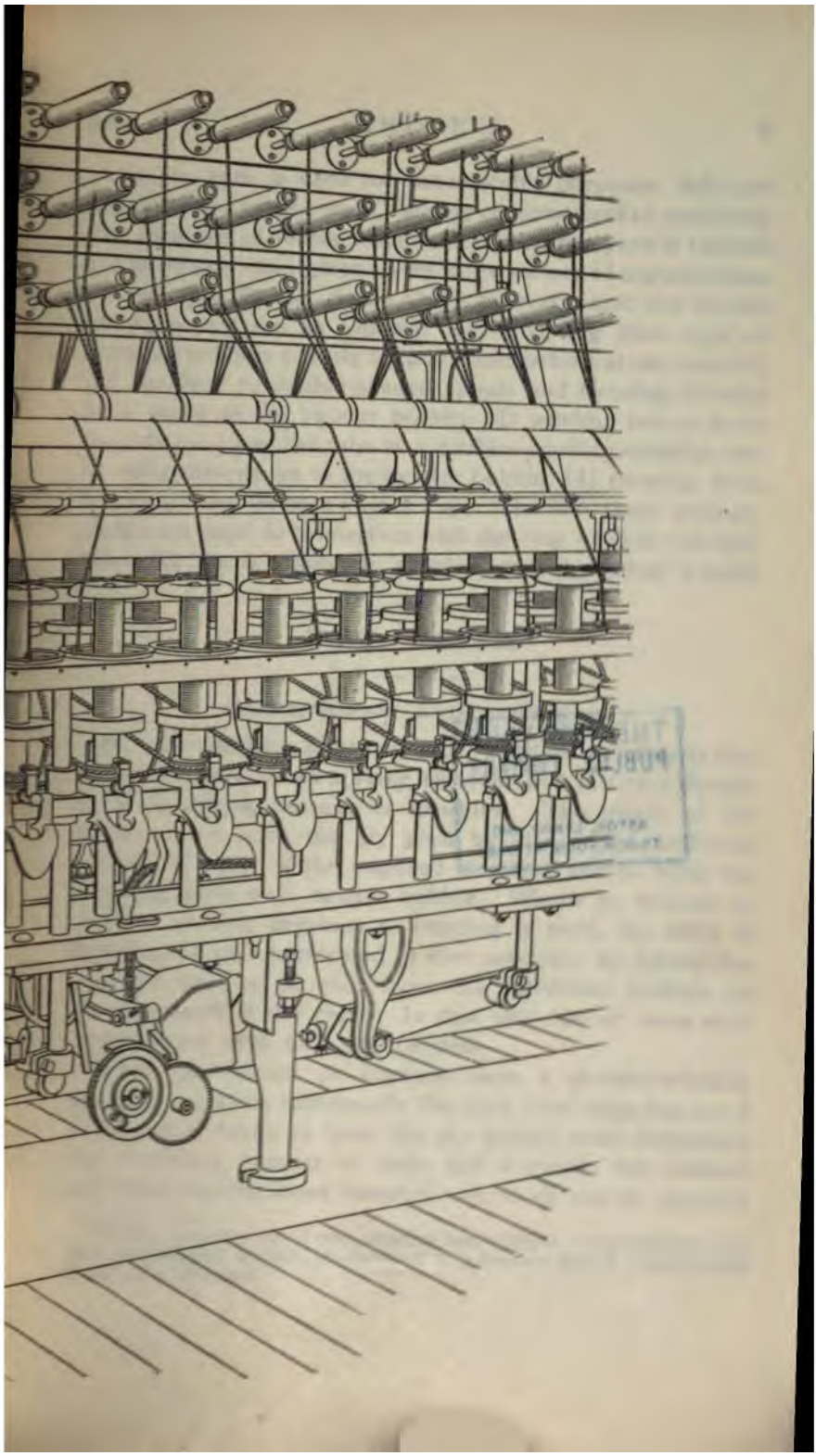
GENERAL CONSIDERATION

8. The twisting process may be performed on machines of various types, depending on two distinct factors: (1) the condition of the yarn when it is being twisted and (2) the method employed to insert the twist. The yarn is twisted in two conditions—wet or dry—giving the names *wet twisters* and *dry twisters* to the two types of machines.

Yarn may be twisted in machines involving three methods of inserting the twist: (1) by the use of a frame with spindles, rings, and travelers on the principle of a ring spinning frame, which is known as a *ring twister* and is the most common type of twisting machine; (2) by means of spindles and flyers on a machine known as a *flyer twister;* (3) by the use of a machine constructed on the mule-spinning principle, known as a *twiner*. Other points of difference in the various methods of twisting are the forms in which the single yarn is delivered for twisting and the forms in which it is removed from the twister. Yarn may be twisted from cops, spinning bobbins, double-headed spools, parallel tubes, taper-wound spools, and, less frequently, conical tubes. It may be twisted on to double-headed twister bobbins, single-headed twister bobbins, either warp- or filling-wind, or cops.









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As ply yarn is used for innumerable purposes, different combinations of processes, varying constructions of machines, and varieties of forms from or to which the yarn is twisted are necessary; this gives a very large variety of organizations for twisting plants. Some of the most common and simple arrangements are as follows: (1) Twisting from cops or spinning bobbins directly to the twister bobbin at one process, (2) spooling to double-headed spools and twisting directly from these to the twister bobbin, (3) winding two or more threads on a parallel tube at a doubler-winding machine and twisting directly on to the twister bobbin, (4) twisting from spinning cops on to a twiner cop. The first three arrangements are used in connection with the ring or flyer twisters, while the last is commonly adopted when the twiner is used.

RING TWISTERS*

CONSTRUCTION AND OPERATION

9. The machine most commonly used for twisting is that known in America as a **ring twister** and in Great Britain as a **doubling frame**, or **doubler**. The object of the twister is to form the ply yarn by inserting a sufficient amount of twist in the required direction and to wind the resulting yarn on a twister bobbin. Where no process of doubler winding previous to twisting is used, the work of doubling is also performed in this machine, by taking the required number of ends from the individual bobbins or spools placed in the creel. In this case two or more ends (usually not over five) are twisted.

When the spools or cheeses from a doubler-winding machine are used, customarily the yarn from only one spool or cheese is taken to form the ply thread, since it contains the necessary number of ends laid together, but without any twist having been inserted. It is of course possible

*As the construction of ring twisters resembles in many respects that of ring spinning frames, students of this Section should concurrently study *Ring Frames*.

to take ends from two or more doubler-wound tubes or cheeses, as for example, when making 4-ply, two ends might be wound on one cheese and two on another and these conducted together so as to make a 4-ply yarn; but this is not so commonly done nor is it as satisfactory as to wind the requisite number of ends on one cheese, if the number required is not excessive.

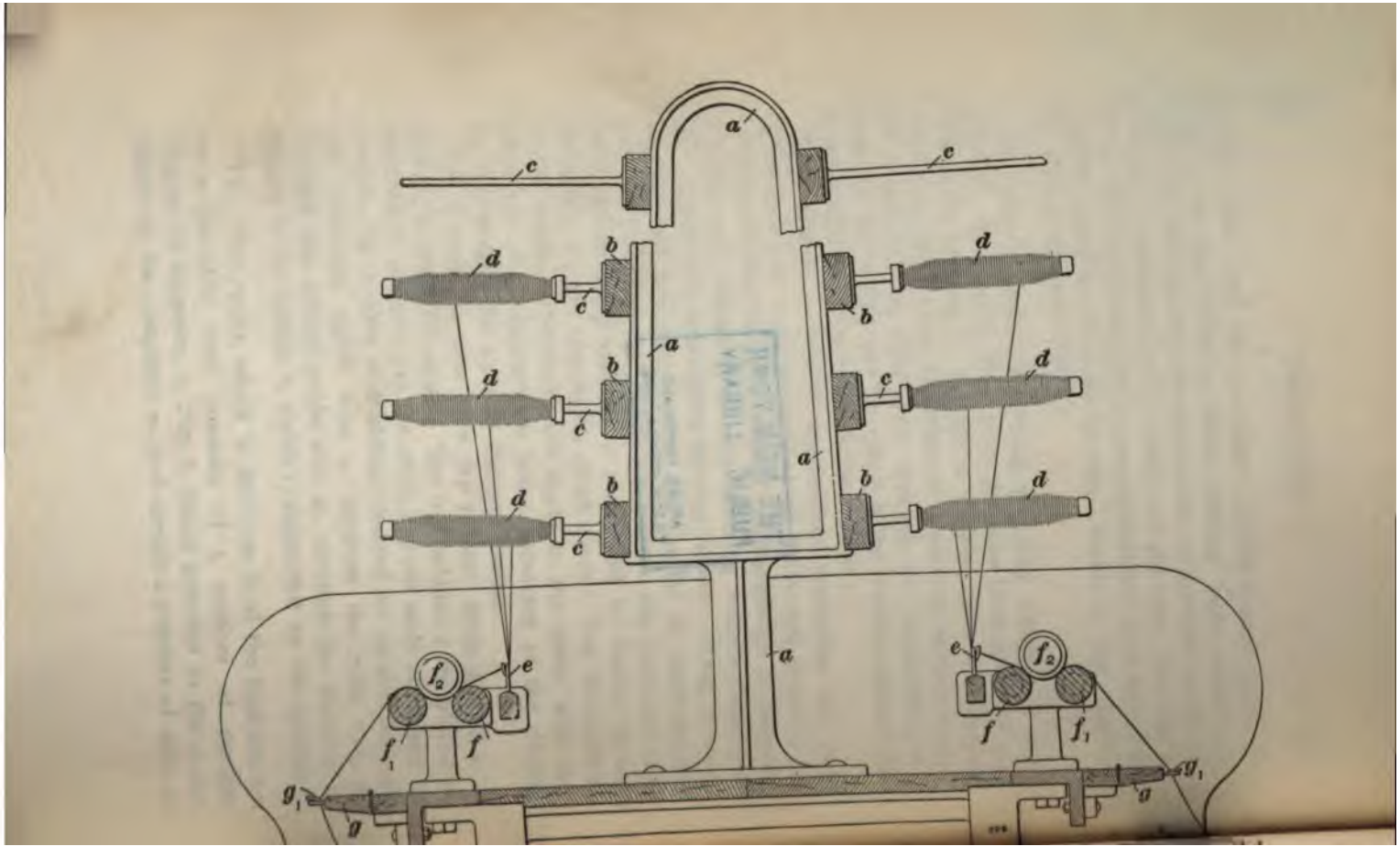
10. The principle on which the ring twister is constructed and operated is to pass the yarn between rolls and twist it by passing it through a traveler that is revolved rapidly around a ring, by means of a rotating spindle carrying a bobbin; the difference between the circumferential speed of the bobbin and the speed of the traveler causes the twisted yarn to be wound on the bobbin.

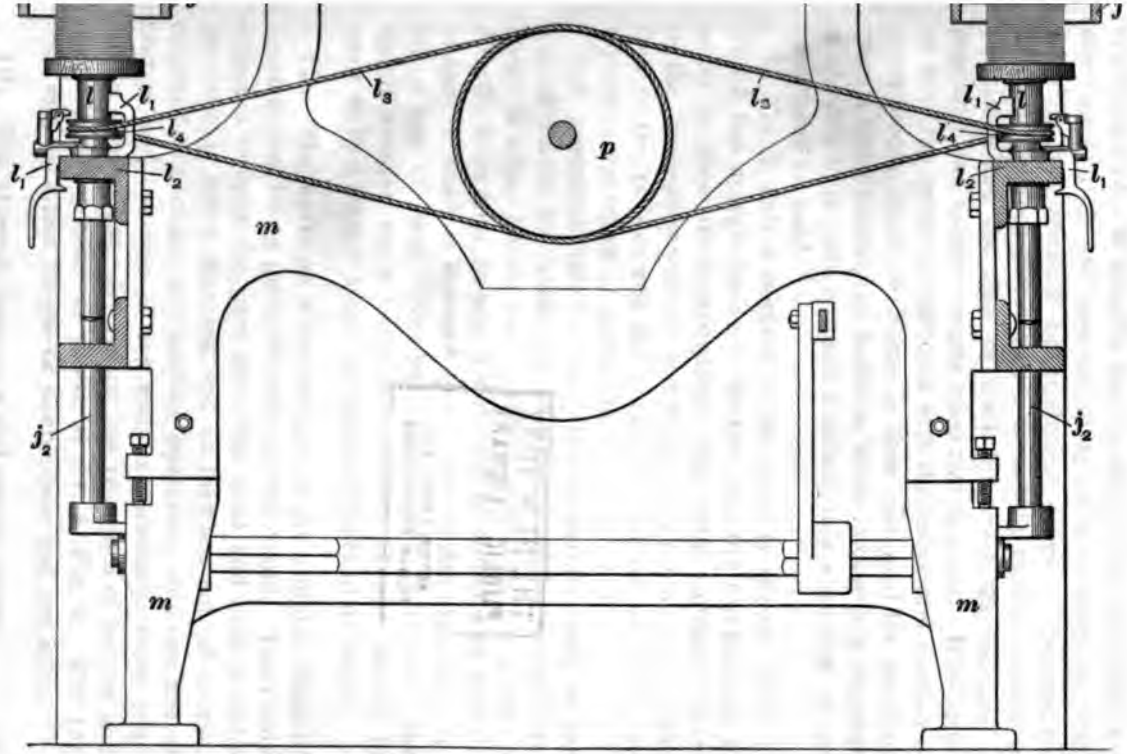
The twister, in general appearance, resembles the ring spinning frame, a large number of parts and motions of which are duplicated on a twister. A knowledge of the construction and operation of ring spinning frames, therefore, aids considerably in studying the ring twister. Ring twisters for both wet and dry twisting are similar in construction, with the exception that in the wet twister, the yarn immediately before being twisted is moistened by being passed through a trough containing clean water. The description of one twister, therefore, will apply to the other, with the exception of an explanation being necessary of the device for moistening the yarn in the wet twister.

Fig. 2 shows a view of a dry twister, while Fig. 3 is a section through the same. The full bobbins *d* are placed in position on the pins *c* in the creel, and the ends necessary to produce the number of doublings desired are passed through the stationary guide wire *e*, between the rolls f, f_1, f_2, through the second guide wire g_1, through the traveler *h*, and on to the bobbin *k*, which is supported by the spindle *l*.

11. The **creel**, which in this case is of the type known as a *porcupine creel*, consists of a number of upright frames, or supports, *a*, Fig. 3, firmly attached to the cross-beams of the sampsons *m*, and carries a number of rails or

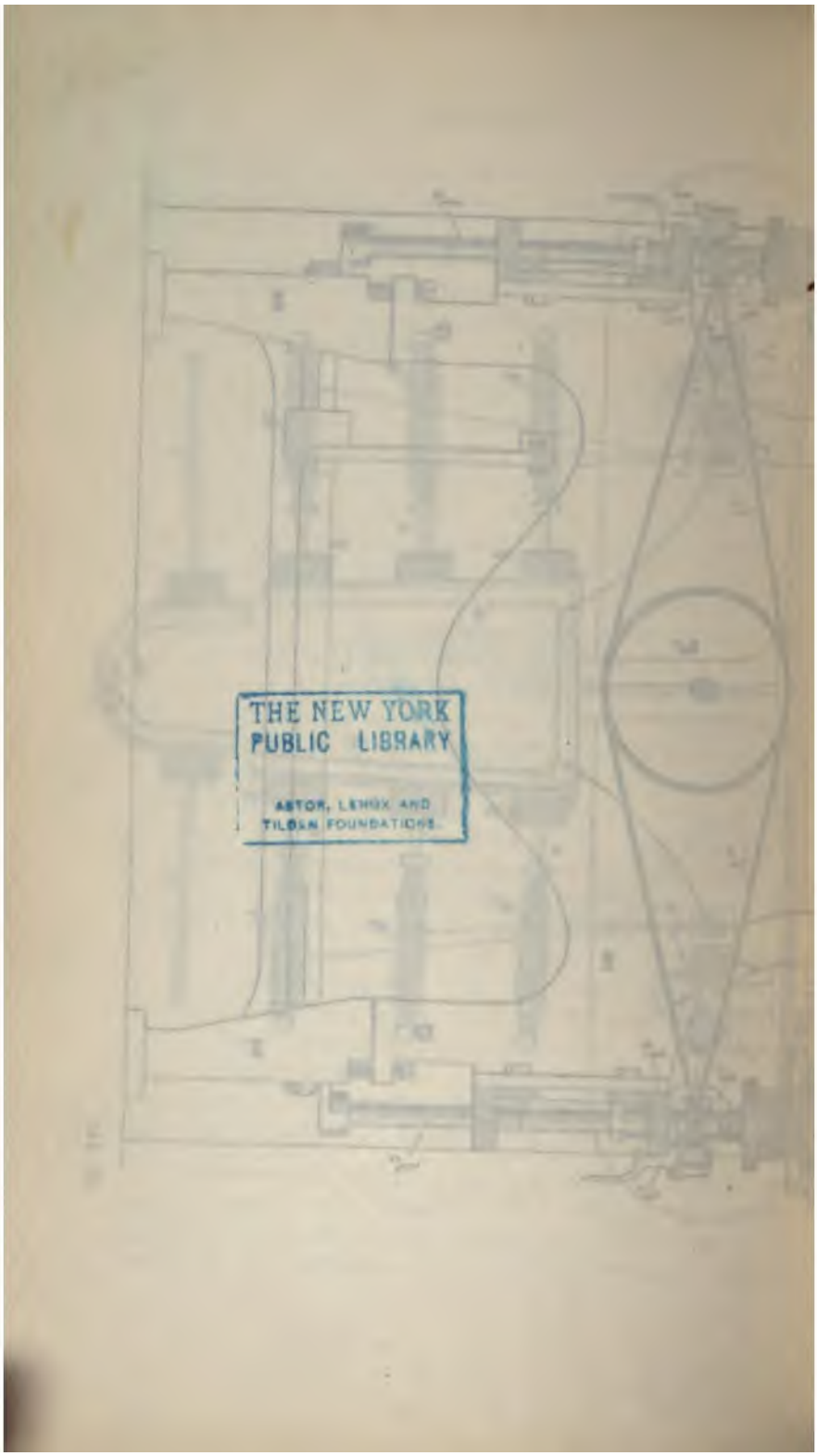
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FIG. 3


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cross-pieces *b*. It must be double-sided, since the frame has one row of rolls and one row of spindles on each side, thus forming two delivery, or producing, sides. The number of rows of cross-pieces varies according to the number of doublings and the class of work for which the machine is intended, and usually ranges from two to eight. It is better to have the creels constructed with the maximum number of cross-pieces, since the frame is then equipped for doubling from a large number of bobbins, while in case it is required to double from only a small number, only a portion of the creel need be used.

In Fig. 2, only a portion of the creel is shown, while in Fig. 3 the upright frame is broken and the top lowered in order to show its construction. The total number of pins in the cross-pieces varies according to the number of spindles in the twister and the maximum number of doublings for which the frame is intended.

The porcupine creel is the style generally used in the United States, but creels can be constructed for special purposes in other forms; as, for instance, a creel for doubling directly from cops, in which rails are provided with sockets in each of which is inserted an iron or wooden skewer carrying a cop of yarn. Another construction is to have the spools revolve on a horizontal wooden skewer placed in steps as in a warper creel, or on skewers set at an angle.

12. The **rolls** on a twister are of the simplest form of construction, being perfectly smooth and round. Their only object is to draw the yarn from the creel and hold it while the twist is being inserted, and as they are not, of course, required to perform any drafting operation, only one line of bottom and one line of top rolls is necessary; more commonly, however, the dry twister has two lines of bottom and one line of top rolls, as shown at f, f_1, f_2, Fig. 3. The top rolls may be either single- or double-boss and are solid.

13. The **thread boards** g and **guide wires** g_1 do not require a detailed description as they are of common construction. The boards are in sections and are hinged, while

the guide wires are adjustable, so that they may occupy their proper position in relation to the spindles. The guide wires serve as guides and retainers for the yarn during its passage from the rolls to the bobbins. They are usually made of steel for the dry twisters, and of brass or enameled iron wire for the wet twisters.

14. Rings.—Two general styles of rings are used on twisters, one for the dry and the other for the wet. Those used on the dry twister, known as the *flat-top* type, resemble very closely the rings of a ring spinning frame except that they are larger and are inserted directly in the ring rail instead of being placed in a ring holder. The ring j_1 is shown in position in the ring rail j in Fig. 3. The traveler, ring, and a portion of the ring rail of a dry twister are also shown in Fig. 4 (*a*). The ring can be adjusted within certain limits so as to be concentric with the spindle. The ring used on the wet twister is generally of the *straight* or *vertical* type; it is shown in position in the ring rail with traveler mounted in Fig. 4 (*b*).

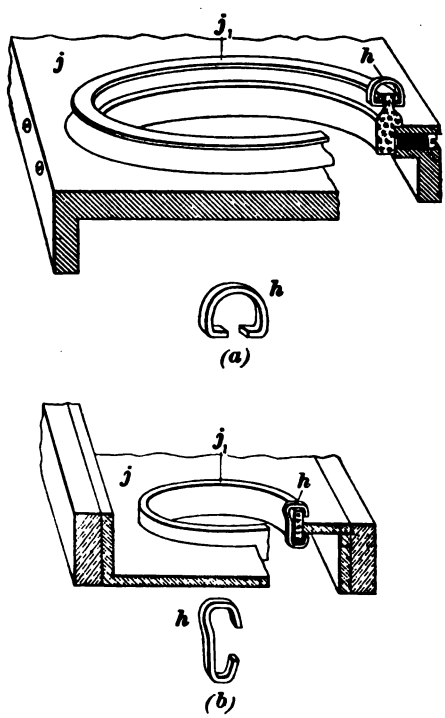


FIG. 4

The rings vary in size according to the kind of bobbin to be used and the work to be produced, as does also the gauge of the spindles. The spindle gauge is usually 1 inch greater than the diameter of the rings.

Table I gives standard sizes of rings and space of frames, that is, gauges of spindles in the frames.

15. The **travelers** for dry twisters are small, narrow, steel clips bent in the form of a semicircle, with two inwardly projecting lugs, formed by the two ends, that fit around the ring and prevent the traveler flying off when it is revolving rapidly. A traveler *h* is shown in position on the ring j_1, Fig. 3. Two kinds of travelers are used for dry twisting—the *round-pointed* and the *square-pointed*. Fig. 4 (*a*) shows a square-pointed traveler *h* mounted on the ring j_1.

The travelers used for wet twisting, as shown in Fig. 4 (*b*), differ greatly from those used for dry twisting; they are usually made of bronze or a composition of metals, so that they will not rust from the moisture deposited on them by the wet thread.

TABLE I

Size of Rings Inches	Gauge of Spindles Inches
$4\frac{1}{2}$	$5\frac{1}{2}$
4	5
$3\frac{1}{2}$	$4\frac{1}{2}$
3	4
$2\frac{1}{2}$	$3\frac{1}{2}$
$2\frac{1}{4}$	$3\frac{1}{4}$
2	3
$1\frac{3}{4}$	$2\frac{3}{4}$

16. Ring Rail.—The general shape of the ring rail of a twister is shown at *j*, Figs. 3 and 4 (*a*) and (*b*); Fig. 4 (*a*) shows the type generally used on dry twisters, while Fig. 4 (*b*) shows the rail of a wet twister. The rail shown in Fig. 4 (*b*) is reversible, thus allowing it to be turned over when the upper flanges of the rings become badly worn. This method of construction does away with the necessity of removing the rings from the rail in order to reverse them. The ring rails for dry twisters are usually made of cast iron or steel, while those for wet twisters are made of brass or some other metal that will not rust.

17. The **spindles** used on a twister, shown at *l*, Fig. 3, may be of either the common or flexible type, as desired. Most of the latest frames, however, are furnished with the flexible spindle, since it can be run at a higher speed, produces

better work, and does not wear out as quickly as those of the common type. The spindles, as well as other parts of the twister, are larger than similar parts of the spinning frame, as they are required to perform heavier work.

The number of spindles in the length of the frame, that is, the total number on both sides, varies from 64 to 240; thus, in a 64-spindle frame there are 32 spindles on each side, and in a 240-spindle frame there are 120 spindles to a side.

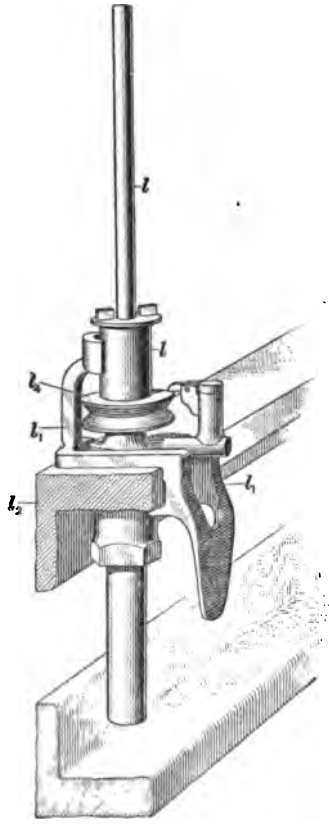


FIG. 5

18. Spindle Brake.—In some cases, for instance where heavy spindles and large bobbins are used, a knee, or friction brake is applied to each spindle in order to stop the spindle from revolving while piecing up an end. This brake, which is shown at l_1, Figs. 3 and 5, rests on the spindle rail l_2. When it becomes necessary to apply the brake, the knee of the attendant is pressed against the outer face, forcing it in toward the rail and causing the inner arm, which contains a friction pad, to come in contact with the barrel of the spindle and thus prevent its revolving. The use of this brake greatly facilitates the piecing process, since it allows the use of both hands in performing the operation.

19. Winding.—Builders may be used on twisters that will build bobbins with a straight wind and heads of equal size, Fig. 6 (*a*); bobbins with a long wind with tapered top, Fig. 6 (*b*); bobbins with a long wind with the upper head

smaller than the lower one, Fig. 6 (*c*); or bobbins with a filling wind, Fig. 6 (*d*). The various forms of winding are determined by the motion and position of the ring rail, which is actuated and controlled by the builder, through the lifter rods. Twisters are built with combination builders or with permanent builders. A perspective view of a combination builder is shown in Fig. 7 (*a*), while a view of the chain connection between the builder arm and the lifting arm is shown in Fig. 7 (*b*).

The shaft *t*, Fig. 7 (*a*), is driven by gearing from the head end of the frame and carries two cams, one of which *s* is heart-shaped, while the other s_1 contains three lobes. Either

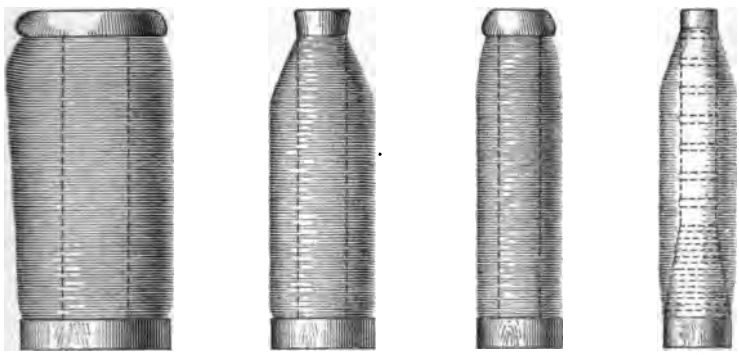
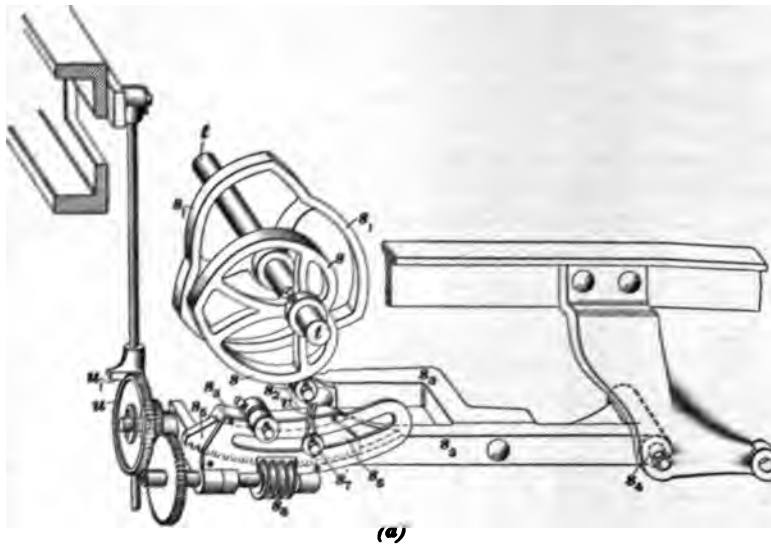


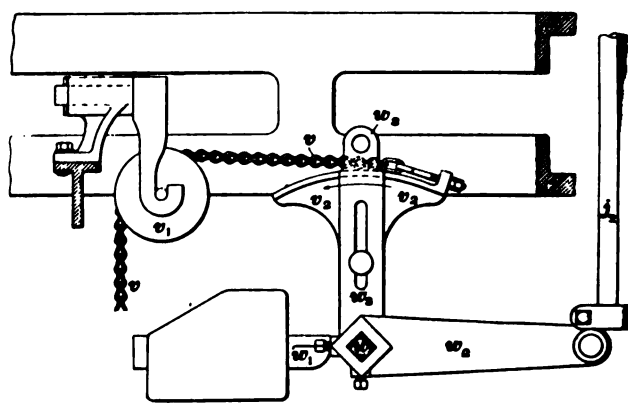
FIG. 6

cam can be used by so adjusting it on the shaft *t* that its surface will be in contact with a bowl s_2 supported by the builder arm s_3. In Fig. 7 (*a*), the cam *s* is in use and s_1 is inoperative. The builder arm is centered at s_4 and carries at its opposite end a rack s_5 that receives motion from a worm s_6. This worm is on a short shaft and receives motion from a ratchet gear *u* operated by a pawl. The rack s_5 carries a stud s_7, to which is attached a chain *v* that passes upwards and over a guide pulley v_1, Fig. 7 (*b*), and is attached to a quadrant arm v_2. The quadrant arm is attached to a shaft *w* that extends across the frame and is supported at each side by brackets. Attached to the central part of this shaft are

two weighted levers similar to w_1 that serve to almost balance the ring rail as it rises and falls. At each end of the shaft is



(a)



(b)

FIG. 7

also a short arm w_2 that carries a bowl on which the foot of the lifter rod j_1 rests.

As the cam-shaft t, Fig. 7 (a), revolves, the cam that is in ɔntact with the bowl s_3 will revolve slowly, and will gradu- ly force down the bowl and consequently the outer end of ıe builder arm. As the outer end of the builder arm is ːpressed, the chain v will be drawn down and, in turn, will aw the quadrant arm v_3, Fig. 7 (b), in the direction of the row, thus raising the outer end of the arm w_3, and conse- ently the ring rail. When the highest part of the cam has ssed the bowl, the excess weight of the ring rail over that the balance weights depresses the lever w_3, Fig. 7 (b), ıusing the quadrant arm v_3 to swing to the right and raise ɜ outer end of the builder arm s_3, Fig. 7 (a). As the outer d of the builder arm rises, it brings with it the rack, ratchet, d their various connections. The teeth of the ratchet come ːo contact with the pawl u_1, which forces the ratchet gear ɔund for a certain distance, thus imparting motion to the ɹrm; this forces the rack to the right, giving a shorter lever- e to the builder arm and, consequently, a shorter traverse the bobbin.

In a long frame, there are a number of cross-shafts similar w; each carries the weighted levers and lifting arms, but ıly the one near the builder carries a quadrant and chain nnection. Each cross-shaft carries a vertical arm similar w_3, while all the arms are connected by means of a long d, so that any motion imparted to the arm w_3 is trans- rred to the others, thereby uniformly raising and lowering ıe ring rail.

By using either cam s or s_1 and making necessary adjust- ıents, various forms of bobbins can be made. The cam s used for building a bobbin with a long traverse, after the ːyle of Fig. 6 (a) or (c), while the cam s_1 is used for build- ıg bobbins, like (b) and (d), with a quick, short traverse.

20. Stop-Motion.—In case the end of twisted yarn reaks between the rolls and the spindle when no stop- ıotion is used, it laps around one of the rolls until cut off nd pieced up by the attendant. Not only does this cause ːaste, but the laps are often difficult to remove and, in

removing them, the rolls are cut or marked; sometimes the end will lash around and break other ends. In order, therefore, to prevent waste and avoid defects, stop-motions are sometimes applied to prevent any more yarn being drawn from the creel after an end breaks at the front of the machine. Machines equipped with such motions can sometimes be run more rapidly, thus increasing the production.

A simple yet effective stop-motion applied to dry twisters having only two lines of rolls is shown in Fig. 8 (*a*) and (*b*). Fig. 8 (*a*) is a perspective view, showing the position of the various parts when the frame is running. The journal *a* of the top roll *b* supports a metal plate, or arm, *c* that carries a

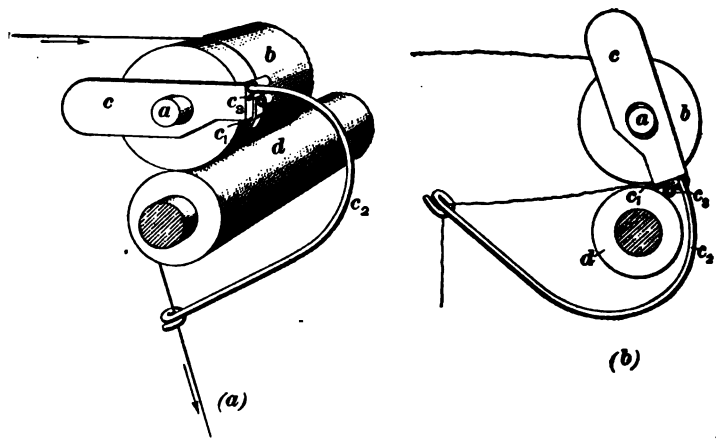


FIG. 8

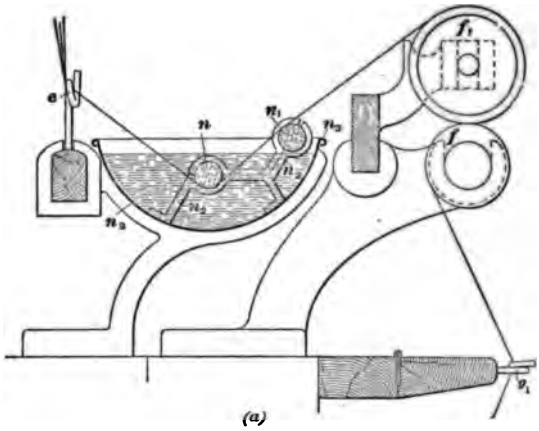
small tongue c_1 and a tension, or knock-off, wire c_2. The tension wire extends outwards from the arm and passes downwards, carrying at its opposite end an eye, or loop, for the yarn to pass through. The tension of the yarn between the bottom roll *d* and the traveler is sufficient to hold the entire mechanism in the position shown in Fig. 8 (*a*). When the yarn breaks, the weight of the wire causes it to fall downwards until the tongue c_1 comes in contact with the rolls and is fed in between them; this raises the top roll and prevents the rolls drawing any more yarn from the creel for that set of rolls. The position that the various parts

y when the stop-motion has acted is shown in the end Fig. 8 (*b*). The lip c_3 prevents the tongue being fed gh the rolls, as it comes in contact with the bottom roll, hus prevents any farther downward movement of the notion. The rear portion of the arm *c* can be extended to show above the rolls and thus attract the attention : operative to the fact that an end is broken.

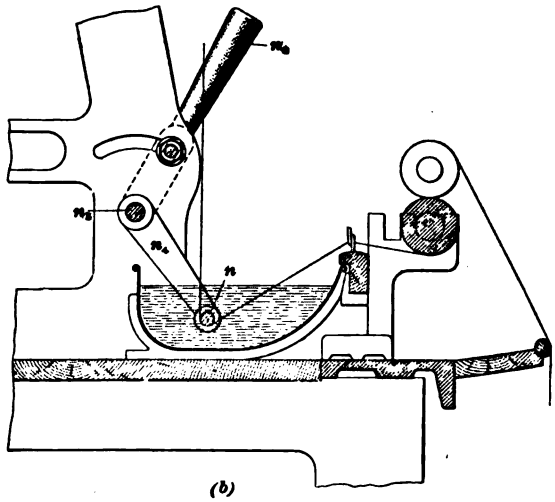
s arrangement is most effective on twisting frames ıg 2-ply yarn, since if only one end of single yarn s, the other end untwists, on account of the direction of in the ply yarn being customarily opposite to that of ngle yarn, and thus the stop-motion acts in case either e single ends breaks. When twisting 3-ply or more, ıotion is only effective in case the complete twisted breaks, and does not detect a breakage of one of the ends and stop delivery.

Method of Wetting the Yarn.—The only point of ɜnce in the construction of a wet and a dry twister is the ation of a contrivance on the former for wetting the immediately before it is twisted, using rolls, guides, avelers constructed of suitable material to resist rust, lso a different-shaped ring and traveler. The object of ; to enable the single yarns forming the ply yarn to lie closely together, thus producing a more solid, smoother, ightly stronger yarn, in which the fibers that otherwise project from the surface of the thread are laid more y to the body of the yarn and in which the twist that is ed *sets* better, or retains its position better, than is the with dry-twisted yarn.

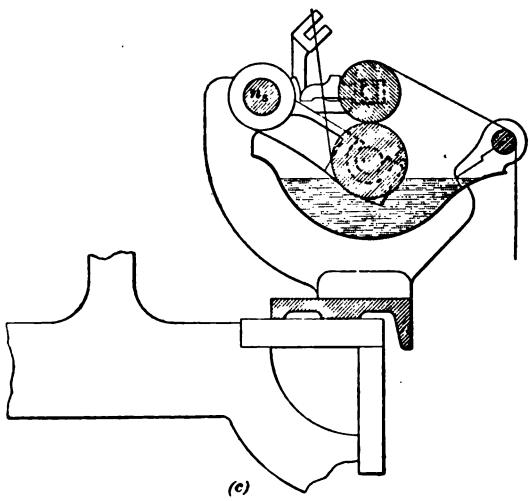
. 9 (*a*) shows a section through the apparatus usually ed on American frames to wet the yarn. The number ls necessary to form one strand of the finished yarn are d through the guide wire *e*, under the glass rod *n*, which merged in the water in the trough n_2, over the glass , which is situated near the front of the trough, over round the top roll f_1, then around the bottom roll *f*, and gh the guide wire g_1, which is situated directly over the



(a)



(b)



(c)

FIG. 9

indle. The trough, which may be built in either short or ıg sections, is usually made of copper, brass, or some other ɛtal that will not rust, and is situated directly back of the lls, as shown in the figure. In the frame under descrip- n the glass rods n, n_1 are supported by brackets similar to ıt shown at n_2; these are attached to the bottom of the ıugh. In some makes of frames these glass rods are sup- rted by means of brackets attached to a long, horizontal l that, in turn, is attached to the roll beam, or in some ɜes to the creel stands.

One style of wet twister, used in the so-called *English tem*, is shown in Fig. 9 (*b*), in which the glass rod n is ɔwn passing through an arm n_4 on the rod n_3, which also ries a handle n_5. When the handle is pulled forwards, the ıss rod is pressed down almost to the bottom of the trough, l the frame is used for wet twisting. By throwing back handle n_5, the glass rod is raised from contact with the ter and the frame can be used for dry twisting.

The wet twister used in the *Scotch system* is shown in g. 9 (*c*). In this case a shallow trough is used, immedi- ly above which are placed two rolls. The yarn passes der and around the lower roll and is delivered from the ɔ roll; both of these rolls are mounted on arms adjusted a horizontal rod n_3, which is so arranged that it can partly rotated from one end of the frame and the rolls sed or lowered. Only the lower roll comes in con- t with the water; from this the yarn absorbs moisture, me of the excess being pressed out by the weight of the per roll.

Both the English and the Scotch systems provide a con- nient arrangement by which the yarn can be taken out of water instead of it being necessary to empty the trough ıen the twister has to be stopped for any considerable ıgth of time.

22. Gearing.—The frame under description is driven rectly from a pulley on the main shaft of the room, by a lt driving a pulley on the cylinder shaft of the machine,

which should make about 1,000 revolutions per minute. Also on the cylinder shaft, as shown in Fig. 10, is the cylinder gear p_1 of 20 teeth, which in this case is considered as the twist change gear.

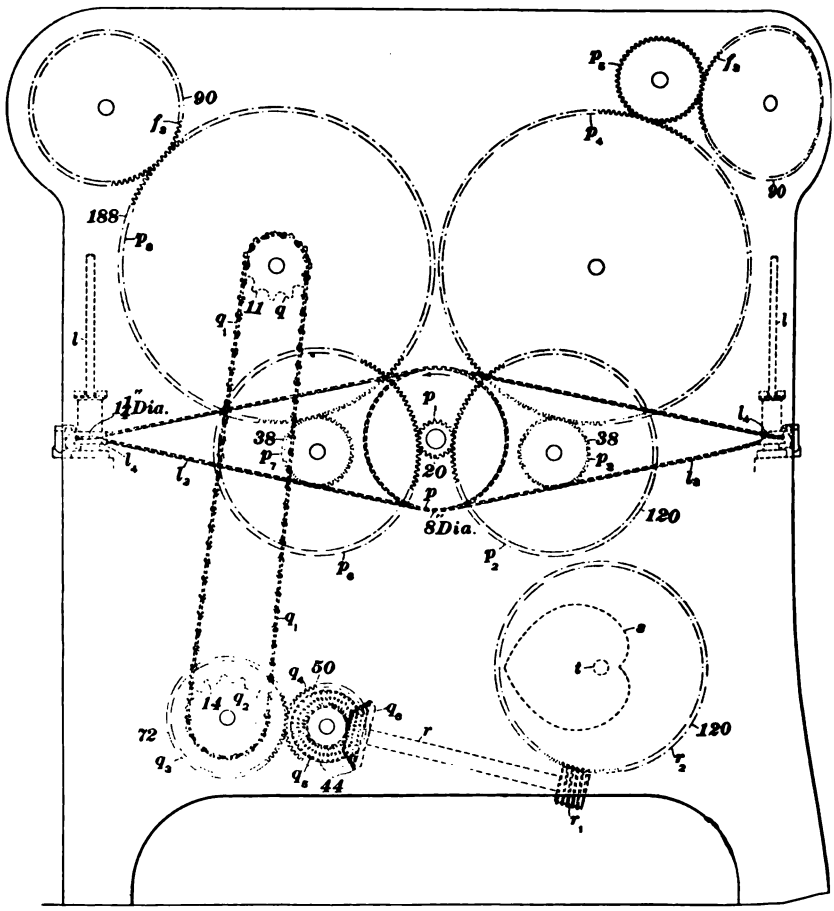


FIG. 10

The front rolls f_1, Fig. 3, are driven from the cylinder gear in the following manner, referring first to the gearing on the right in Fig. 10. The cylinder gear p_1 drives the

driven stud gear, or jack-gear, p_3, which is compounded with the driving stud gear p_2. This latter gear is used as a twist change gear on this frame when the necessary twist cannot be obtained by changing the cylinder gear. On some makes of frames, the driving stud gear p_2 is considered as the principal twist change gear and altered for all changes of twist. The driving stud gear drives the roll gear f_3 through two carrier gears p_4, p_5. For the left-hand side, the cylinder gear p_1 drives the driven stud gear p_6, which is compounded with the driving stud gear p_7, which in turn drives f_3 through the carrier p_8. On the shaft with the gear f_3 is a gear f_4, Fig. 11, that drives the gear f_6 on the front-roll shaft, while on the same shaft is a gear f_8 driving, through a carrier gear, the gear f_7 on the back-roll shaft. The gears f_6, f_7 are of the same size, and the front and back rolls are of the same diameter, so that the surface speeds of both rolls are the same.

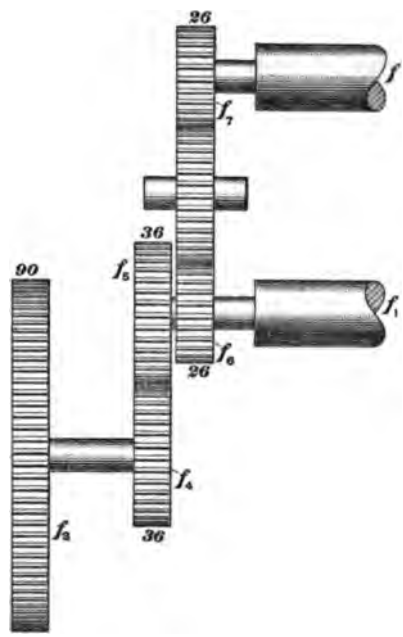


FIG. 11

The cylinder p, Figs. 3 and 10, which is 8 inches in diameter, drives the spindles by means of bands, similar to l_3, that pass around the whorl l_4 of the spindle l.

The builder receives its motion from a sprocket gear q, Fig. 10, that is compounded with the carrier gear p_8. The gear q drives, by means of a chain q_1, the sprocket gear q_2, which is fastened to a short shaft on which the gear q_3 is situated. The gear q_3 drives the gear q_4 on a short shaft with the bevel gear q_5, which drives another bevel gear q_6 on

the angle shaft r. The angle shaft carries at its opposite end a single-threaded worm r_1 driving a worm-gear r_2 on the shaft with the cams that operate the builder motion.

CALCULATIONS

23. Twist.—The only calculations that are of importance in connection with twisters are: (1) those that are useful in determining the twist per inch inserted in ply yarn and (2) those that are useful in determining the production of a twister. As there are no draft rolls in a twister, the subject of drafts, of course, does not enter into any calculations. The subject of twist per inch is a very important one, both the calculation necessary to determine, with a given multiplier, the turns per inch that ought to be inserted in any yarn and also the turns per inch that are actually inserted.

EXAMPLE 1.—Find the speed of the cylinder when the main shaft of the room makes 395 revolutions per minute and carries a 30-inch pulley driving a 10-inch pulley on the cylinder shaft.

SOLUTION.— $\frac{395 \times 30}{10} = 1{,}185$ rev. per min. of the cylinder. Ans.

EXAMPLE 2.—Find the speed of the front roll of the twister under description, geared as shown in Figs. 10 and 11, when the cylinder makes 1,185 revolutions per minute.

SOLUTION.—

$$\frac{1{,}185 \times 20 \times 38 \times 36}{120 \times 90 \times 36} = 83.388 \text{ rev. per min. of the front roll. Ans.}$$

EXAMPLE 3.—Find the number of inches delivered per minute by the front roll when it makes 83.388 revolutions per minute and is $1\frac{1}{2}$ inches in diameter.

SOLUTION.— $83.388 \times 1\frac{1}{2} \times 3.1416 = 392.957$ in. per min. Ans.

EXAMPLE 4.—Find the speed of the spindles when the cylinder is 8 inches in diameter and makes 1,185 revolutions per minute, the spindle whorl being $1\frac{1}{4}$ inches in diameter.

SOLUTION.—If the exact diameter of the cylinder and the smallest diameter of the whorl are taken, accurate results are not obtained, as some allowance should be made for the diameter of the spindle band, which is usually $\frac{1}{8}$ in. The most correct way is to make an allowance for this both on the diameter of the cylinder and of the spindle whorl, but it is more convenient and gives sufficiently accurate results to use the actual diameter of the cylinder but add $\frac{1}{8}$ in. to the diameter of the

spindle whorl at its smallest part. This is the practice that is followed in this Section.

$$\frac{1{,}185 \times 8}{1\frac{3}{8}} = 6{,}894.545 \text{ rev. per min. of the spindles. Ans.}$$

EXAMPLE 5.—What is the twist per inch being inserted in the yarn, if the front roll delivers 392.957 inches per minute and the spindles make 6,894.545 revolutions per minute?

SOLUTION.— $6{,}894.545 \div 392.957 = 17.545$ turns per in. Ans.

NOTE.—Some millmen make a deduction from the calculated result of 5 per cent. to allow for slippage and loss in winding, but this should not be done, as the yarn contracts during the process of twisting in about the correct proportion to compensate for such slippage.

EXAMPLE 6.—Find the twist per inch being inserted in the yarn by figuring through the gears from the front roll to the spindles, thus ascertaining the number of revolutions of the spindles per inch delivered by the front rolls.

SOLUTION.—

$$\frac{36 \times 90 \times 120 \times 8}{36 \times 38 \times 20 \times 1\frac{3}{8} \times 1\frac{1}{4} \times 3.1416} = 17.545 \text{ turns per in. Ans.}$$

EXAMPLE 7.—Find the constant for twist by figuring through the gears from the front roll to the spindles, adding $\frac{1}{8}$ inch to the diameter of the whorl and considering p_1 as the twist change gear.

SOLUTION.—

$$\frac{36 \times 90 \times 120 \times 8}{36 \times 38 \times 1 \times 1\frac{3}{8} \times 1\frac{1}{4} \times 3.1416} = 350.901, \text{ constant. Ans.}$$

EXAMPLE 8.—Find the twist per inch being inserted in the yarn with a 20-tooth twist gear, if the constant is 350.901.

SOLUTION.— $350.901 \div 20 = 17.545$ turns per in. Ans.

EXAMPLE 9.—Find the twist gear required to produce 17.545 turns per inch if the constant is 350.901.

SOLUTION.— $350.901 \div 17.545 = 20$, or 20-tooth twist gear. Ans.

24. It is an important matter for any person having charge of twisters to determine the correct constant for each kind of twister under his charge; that is, each twister that is geared differently. Since the constant may vary according to the diameter of the cylinder, the diameter of the whorl, the twist, or cylinder, gear p_1, Fig. 10, the stud gear p_2, or the diameter of the front roll, a great many tables might be made to show the twist per inch that would be inserted by the different combinations of these factors. Each machine builder usually supplies a table showing the number of turns per inch that are put in by using each different size

of change gear with the train of gears and the sizes of cylinder, whorl, and front roll adopted by that particular firm of builders. The overseer in charge, however, should be careful that in such cases the table in question is not used for any other make of twisters or any other twister made by the same firm if the number of teeth in the train of gears or the other particulars differ in the slightest, since this would result in the yarn being made with the wrong amount of twist. Each overseer can make a twist table of his own by ascertaining the necessary particulars from the frame under his charge, working out the constant in accordance with the method given, and then dividing this constant by each size of change gear, from the smallest to the largest, that is likely to be used; thus, for example, Table II has been prepared from the information already given for a frame geared as shown in Figs. 10 and 11, using a 38 stud gear at p_3 and p_7, Fig. 10, and adding $\frac{1}{8}$ inch to the diameter of the whorl.

TABLE II

Teeth in Cylinder Gear	Twist	Teeth in Cylinder Gear	Twist
18	19.494	30	11.696
19	18.468	31	11.319
20	17.545	32	10.965
21	16.709	33	10.633
22	15.950	34	10.320
23	15.256	35	10.025
24	14.620	36	9.747
25	14.036	37	9.483
26	13.496	38	9.234
27	12.996	39	8.997
28	12.532	40	8.772
29	12.100		

25. The amount of twist to be inserted in yarn is usual specified by the buyer of the yarn by means of a *multiplic*

which is a number that, when multiplied by the square root of the counts of the single yarn to which the ply yarn under consideration would be equal, approximately indicates the turns per inch to be inserted. These multipliers vary very largely, since they are determined mainly by experience. A buyer of ply yarn or a mill using ply yarn may need it for a purpose that requires the yarn to be full and softly twisted, or it may be required to be hard and firmly twisted. The multiplier varies for yarns of a similar name when used by different firms, even when the yarns are of the same counts, so that before making a ply yarn for sale it is quite important to ascertain what twist is required. The range of multipliers is from 2.5 to 6.5. The smallest are used for mending yarns, knitting yarns, and embroidery yarns, since these are commonly required to be soft, full yarns; larger multipliers are used for yarns intended for sewing threads, while the largest are for such yarns as those intended for fishing nets, macramé, and other hard twines, harness yarn, etc.

EXAMPLE 1.—Find the turns per inch to be inserted in 72s 2-ply, using 5 as a multiplier.

SOLUTION.—Considering the 2-ply yarn as a single yarn, its counts would be

$72s \div 2 = 36$. $\sqrt{36} = 6$. $6 \times 5 = 30$ turns per in. Ans.

EXAMPLE 2.—What twist per inch should be inserted in 85s 5-ply with a multiplier of 6?

SOLUTION.—

$85s \div 5 = 17$. $\sqrt{17} = 4.1231$. $4.1231 \times 6 = 24.738$. Ans.

From these examples it will be seen that the method of arriving at the number of a single yarn that would be equal to the ply yarn is to divide the counts of the component single yarns, by the number of ply, as for example, $72s \div 2 = 36s$; $85s \div 5 = 17s$. As a matter of fact, in each case the ply yarn will be rather coarser than this, because of the contraction in twisting; but it is not customary for ordinary purposes to take this contraction into consideration.

26. In some districts in the United States, it is customary to take as a multiplier a number that, when multiplied by the

square root of the counts of the single yarn used to form the ply yarn, gives the turns per inch in the ply yarn; this is also a common method in Europe. It is therefore always important to understand whether a multiplier is to be considered as multiplying the square root of the counts of the single yarn, forming the ply yarn, or of a single yarn that would be equivalent to the completed ply yarn, since in the latter case the multiplier is larger than in the former.

EXAMPLE.—What multiplier would be used with which to multiply the square root of the single yarn in order to give 30 turns per inch in 2-ply 72s?

SOLUTION.— $\sqrt{72} = 8.485$. $30 \div 8.485 = 3.5$. Ans.

The multiplier in this case, 3.5, when multiplied by the square root of the counts of the single yarns forming the ply yarn, gives 30 turns per inch, just as the multiplier 5 gave 30 turns per inch in a previous example when multiplied by the square root of 36, which was considered as the counts of a single yarn equivalent to 2-ply 72s.

27. Production.—As twisters are not provided with hank clocks, the production is generally figured directly from the front roll, which gives only a theoretical production.

Rule I.—*To find the number of hanks per spindle, multiply the number of inches delivered per minute by the total number of minutes run, and divide the product thus obtained by the number of yards per hank multiplied by 36 (the number of inches per yard). From this calculated production, a certain percentage should be allowed for stoppages.*

EXAMPLE 1.—If the front roll delivers 392.957 inches per minute, what is the production for 1 week of 60 hours, allowing 6 per cent. for stoppages?

SOLUTION.— $\frac{392.957 \times 60 \times 60}{840 \times 36} = 46.780$ hanks per spindle per wk.

$.94 \times 46.780 = 43.973$ hanks. Ans.

The allowance of 6 per cent. in this example is not accurate for all kinds of twisting, for this varies from 5 to 20 per cent. The allowance is intended to compensate for the amount of time lost in stopping the frame for doffing and

various other purposes. It is least in the case of fine yarns, as the frames do not require doffing so frequently, and greatest in the case of coarse yarns. It is also greater when several single yarns are being twisted than when 2-ply yarns are being made. For example, the allowance for 6/2 is usually 14 per cent.; for 6/3, 15 per cent.; for 6/4, 17 per cent.; and for 6/6, 20 per cent. For number 20s, the allowances are 10 per cent., 11 per cent., 12 per cent., and 13 per cent. for 2-, 3-, 4-, and 6-ply, respectively. For 40s, the allowances are 6 per cent. for 2-ply, 7 per cent. for 3-ply, and 8 per cent. for 4- or 6-ply; for number 80s, 4 per cent. for 2-ply, 5 per cent. for 3- and 4-ply, and 6 per cent. for 6-ply. This allowance should not be confused with an allowance sometimes made for slippage, which is an entirely different matter.

Rule II.—*To find the number of pounds per spindle, divide the number of hanks per spindle by the resultant counts.*

EXAMPLE 2.—If a frame produces 43.973 hanks per spindle per week, what is the production per spindle in pounds if two strands of 40s are twisted together?

SOLUTION.— $40 \div 2 = 20$s, resultant counts. $43.973 \div 20 = 2.198$ lb. per spindle per wk. Ans.

28. Floor Space and Power.—The floor space occupied by twisters depends on the number of spindles in the frame and the space between the spindles, or the gauge of the frame. The number of spindles varies from 64 to 240, one-half being on each side of the frame; the regular sizes contain either 180, 208, or 240 spindles. The sizes of rings generally used and the corresponding gauges, or spaces between the centers of the spindles, are given in Table I. The total length of a twister may be ascertained by multiplying the gauge by the number of spindles on one side of the frame, converting the result into feet and inches, and adding 2 feet in case driving pulleys with $2\frac{1}{4}$-inch face are used, for the extra space required for the head end and foot end of the frame. A frame with 180 spindles, $2\frac{1}{2}$-inch rings, and $3\frac{1}{2}$-inch gauge occupies 28 feet 3 inches.

The width of a twister ranges from 3 feet 3 inches to 3 feet 6 inches; the parts resting on the floor occupy about 3 feet 2 inches in width, but the ring rail projects beyond this on either side, a rail with large rings projecting farther than one with small rings. Thus the width of a twister depends somewhat on the size of the rings.

Twisters require approximately 1 horsepower for each 60 spindles, although this varies according to the weight of the spindle, the size of the ring, and the material being twisted. The driving pulleys for the end of the frame are made in various diameters from 10 to 20 inches, and are usually $2\frac{1}{4}$ inches in width, although frames may be supplied with $2\frac{1}{2}$-inch, 3-inch, $3\frac{1}{2}$-inch, or wider, pulleys, depending on the length of the frame and the consequent amount of power required to be transmitted.

FLYER TWISTING FRAMES

29. The older method of twisting yarns was to use a **flyer twisting frame**, and although this has been supplanted to a great extent by the ring-twisting process, it is still used in some districts, especially for coarse work in cotton, such as crochet yarns, harness-making yarns, yarns for fishing nets, etc., and also for yarns from materials that are unusually heavy, such as linen, hemp, and jute yarns. For coarse yarns, it is not possible to obtain a sufficient drag on a ring frame to insure the insertion of the proper amount of twist and regular winding. Flyer twisting frames do not differ in any material points from ring twisting frames except in the spindle and connected parts for inserting the twist and winding the yarn on the bobbin.

Those parts that differ from ring twisters are shown in Fig. 12, and consist of a spindle *a* driven in the usual way from the main cylinder of the frame by means of a band running to a whorl on the spindle, which is considerably longer than a ring-twister spindle and of a common type, without any gravity arrangement. Screwed on its upper end is a two-armed flyer *b*, the end of each arm is curved into a

flyer eye b_1. In order to enable the flyer to be securely attached to the spindle, the latter has a screw thread cut into its upper end, corresponding to the threaded part of the flyer. The yarn delivered from the guide c in the thread board c_1 is passed several times around one of the arms of the flyer b and thence through the eye b_1 and on to the bobbin d. Twist is inserted by the revolution of the flyer, and the yarn wound on the bobbins by their motion being retarded in either of two ways. The method adopted in Fig. 12 makes use of a continuous drag band e tied to pegs similar to the peg e_1 in the rail and passing alternately to the left and right of the bobbins, resting in grooves d_1 provided in them for this purpose; by properly adjusting this drag any desired tension may be obtained, in order to wind the yarn as it is twisted. Sometimes separate drag bands are provided for each spindle with a separate drag weight attached to each band.

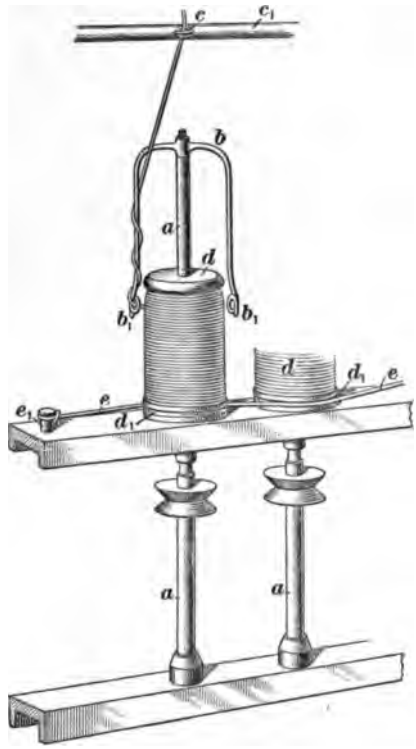


FIG. 12

Flyer twisting frames run much heavier than ring twisting frames, thus absorbing more power; they may be made for either wet or dry twisting.

TWINERS

30. A common method of making cotton ply yarns in Europe is to twist them on a machine somewhat resembling the spinning mule. This is not used to any extent in the United States and no detailed description is necessary. There are two systems of twining, known as *Yorkshire twining* and *French twining*. In both cases the cops of yarn to be twisted are placed in a creel on skewers, so arranged as to allow the yarn to unwind over the nose of the skewer, passing through suitable drag apparatus to allow it to be unwound only at the required rate; the ends are twisted, as in a mule, by the revolution of the spindle, on which the ply yarn is wound in cop form. During that portion of the process when the yarn is actually being twisted, the yarn coming from the creel is held firmly by a compressing arrangement, which enables the twisting to be performed evenly and without snarling the yarns.

In the Yorkshire system of twining, the spindles are stationary, the creel traveling alternately to and from them, which is the exact opposite of the system adopted in mule spinning for single yarns. In French twining, the creel is stationary and the carriage containing the spindles travels, as in the case of mule spinning.

Twiners are constructed with from 800 to 900 spindles each, which absorb considerably less power than the same number of either ring- or flyer-twister spindles. On the other hand, twiners require more skilled help and occupy much more floor space than twisters.

MANAGEMENT

31. The management of twisters involves the usual attention to cleaning, oiling, and adjustment required by most textile machinery, although as the construction of a twister is simple, there are not so many points of adjustment, the absence of drawing rolls especially reducing the number.

32. Oiling.—In those frames where the spindles have oil reservoirs, the reservoirs should be replenished with oil every 2 or 3 weeks. Other constructions of spindles should be oiled oftener, varying from daily for flyer-twister spindles to weekly for common ring-twister spindles. Other quickly running parts of the twister, such as pulleys, cylinder, and rolls, should be oiled daily, while slowly moving parts, such as the builder, should be oiled weekly. In large mills, it is advisable to have the oiling done by a man who devotes his entire attention to the work.

33. Cleaning.—Parts of the twister especially liable to collect dust and lint, such as the ring rail and roll beam, should be wiped off several times a day, preferably at the time the frame is doffed, unless on fine numbers, when a frame is doffed at more remote periods, in which case some other time should be determined on, for example three times a day. The creel should also be dusted at the same time. Once a day, at least, the more prominent parts of the frame, such as the boxed ends, should be wiped; while all parts, such as builder, lifter rods, and sampsons, should be thoroughly wiped twice a week, at which time the creel should have a thorough cleaning also. The spindles should be taken out and cleaned at least twice a year, when the dirty oil may be pumped out of the reservoir and the bolster base and other parts thoroughly cleaned. The ring rail should be taken off and scoured about once a month. Twisting frames used for wet twisting require more attention than those for dry twisting.

34. The single yarns that are being doubled should be as even as possible throughout their length, and it is also important that the two or more ends that are being doubled together should be of the same counts and that there should be as small a range of variation as possible in the size of the single yarns. In case one yarn is much coarser than another or larger in diameter through being slack twisted, there is a liability of the production of what are known as *corkscrewed yarns*, where one of the ends twists

around the other, giving a beaded appearance. For the same reason, it is essential to have the same length of each of the two or more ends of single yarn delivered by the rolls. This is always the case when the single yarns have been doubler-wound, because all the ends leave the tube together; but in case of doubling from cops or bobbins it is essential that each end should be fed to the rolls as far as possible at the same tension. For the same reason, it is also essential that the supply of different numbers of yarn should be kept separate and every precaution taken against mixing the spools or tubes.

35. Piecing.—In case an end breaks, it should be pieced with as small a knot as possible; and as far as possible, bunch knots should be avoided. These occur when the two or more threads forming one end of the ply yarn are tied to the two or more ends forming the other part of the broken thread of the ply yarn, thus resulting in a bulky knot.

36. Missing or Superfluous Ends in Ply Thread. The attendant should keep a careful watch on the ends being delivered by the rolls to see that the correct number is being passed forwards to make the ply yarn. In the case of 2-ply, if one end has broken, the other end will also break in front of the rolls, since in the ordinary method of twisting with the twist in the reverse direction to that in which the yarn is spun, it is impossible for one end to continue to be twisted without the other, as the reverse twist untwists the single yarn and breaks it. In the case of 3-ply or higher, however, it is possible for one of the single ends to break and the others be passed forwards to the bobbin with one end missing; for instance, if 4-ply 40s were being made, the resultant yarn would be approximately equivalent to 10s, but if one end were missing, it would result in 40s 3-ply being produced, equivalent to 13.33s. A missing end of this kind is usually shown by the broken end lapping around the rolls, but this is not always the case since it may be broken in the creel. These are matters that can only be prevented by careful watchfulness on the part of

the attendant and supervision on the part of the overseer. As it is customary to inspect ply yarn before it is shipped to the buyer and throw out defective yarn, it is important to have these points watched, since those bobbins and skeins of yarn that are thrown out as being of second quality are of little value compared to the first-quality yarn.

37. Banding.—It is important that the bands should be well made and securely tied, so that they will not slip, and they should be put on as nearly as possible at an even tension. Slack-twisted yarn is frequently made by slack bands; the frame should therefore be looked over periodically and such bands cut off and replaced wherever soft bobbins are noticed.

38. Bobbins should be well made, smooth on their outside surface, and should fit, and be of proper dimensions for, the spindles on which they are to be used.

39. Travelers should be selected suitable for the numbers of yarn being twisted, the number of doublings, the amount of twist, and the speed of the spindle. This is generally determined both by experience and experimenting. The traveler should be heavy enough to prevent *ballooning*, since separators are seldom used on twisters. By **ballooning** is meant the tendency for the yarn to fly away from the straight line between the guide wire of the thread board and the traveler, on account of the centrifugal force generated by the rapid rotation of the traveler. Ballooning often results in one end catching on another, thus breaking one or both of them, and often causing two ends of ply yarn to be run together on one bobbin. For this reason, the preference is usually given to the heaviest traveler that the yarn will stand without undue tension or breakage.

40. Correct Twist Per Inch.—It is important that all yarn intended to be of the same description shall be twisted uniformly; this makes it necessary to see that the same twist per inch is being inserted at each spindle on the frame, and also on other frames making yarn for the same order. The

first frame started on any order after it has been running a short time should be examined with a view to ascertaining whether the correct number of turns per inch is being inserted. This is done either by placing samples of the yarn in a twist tester and turning the handle until the yarn is completely untwisted and the number of revolutions ascertained, or by examining the thread under a pocket magnifying glass, such as is used in dissecting cloth. The base of the framework of the glass usually has a 1-inch square hole in it, and the number of turns in the 1-inch space can be counted through the glass. It facilitates counting the turns per inch in a white ply yarn to make a short length with one colored end in place of one of the white ones, but of the same counts as the one that it replaces. The twist can then be very easily counted, because of the contrast between the colors. For this purpose it is well to carry in stock a few bobbins of colored yarns of exactly the same numbers as those that are customarily twisted in the mill. The product of each machine should be examined, counting several different samples from each side of each machine, and taking the average. If any appreciable variation is found between one machine and another, the gears should be examined, since there are several gears in each train driving the front rolls that it would be possible to change and, as in some cases change gears are so constructed that they fit in either of two or more positions, there is a liability of error in leaving on or putting on wrong gears when changing.

In case any great change is made in the counts being twisted it is important to either alter the number of teeth taken up at the builder or change the builder gear. Otherwise, in case of changing to finer counts the space between the adjacent coils in each layer of yarn will be too far apart, while in case of changing to coarser counts, one coil will tend to ride over another, thus in either case making a poor bobbin.

41. Creeling is generally performed by the attendant who pieces up broken ends, etc. In the case of twisting from cops or bobbins, knots are produced at different intervals

in various ends of yarn, because all cops or bobbins do not run out at the same time. When twisting from doubler-wound tubes it is customary to put all the tubes in at one time, making all the knots come together. These are then run through the rolls and doffed, so as to reduce the number of knots in the yarn to a minimum.

42. Other matters in management that require attention are to operate the frame so as to obtain as high a production as possible, to have the help economical in the use of travelers, to avoid waste of yarn, and to periodically readjust the frames, properly alining and adjusting the spindles, rings, and guide wires with one another and alining the rolls and cylinders.

SPOOLERS

INTRODUCTION

1. Unlike almost every other machine through which the cotton passes during its process of manufacture into cloth, the **spooler** cannot be said to have any effect on the condition of the stock passing through it, since its only object is to assemble a greater length of yarn and put it in a suitable shape to be unwound at the next process. The yarn comes to the spooler, in most cases, from the spinning frame, although in a few instances, from the mule. The treatment of the cotton in these two machines constitutes the final process of yarn preparation; namely, spinning. This statement refers to single yarn; ply yarn is usually supplied to the spooler on twister bobbins.

If yarn is *frame-spun*, that is, if it has been spun on the spinning frame, it is in almost every case on a wooden bobbin and may be wound in two ways, one being known as a *warp-wind* build of bobbin and the other as a *filling-wind*. Figs. 1 and 2 show warp-wind and filling-wind frame bobbins as they appear when empty and when filled.

2. Fig. 1 (*a*) shows an empty bobbin such as would be used for warp yarn with a **warp wind**; Fig. 1 (*b*) shows the manner in which the yarn is placed on such a bobbin. The yarn is built up in successive layers, the traverse of each succeeding layer being slightly shorter than the one just before it. Thus, as shown in Fig. 1 (*b*), the traverse of the first layer of yarn on this bobbin extends from j_1 to j_2, while the traverse of the last layer extends from j_3 to j_4.

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The yarn in being unwound from such a bobbin is always pulled from the side.

Fig. 2 (*a*) shows an empty bobbin such as would be used for yarn with a **filling wind**; Fig. 2 (*b*) shows the manner in which the yarn is placed on such a bobbin. Instead of

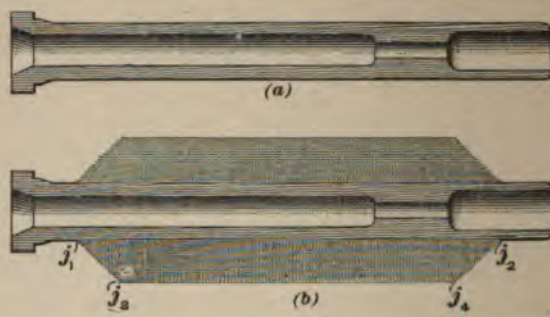


FIG. 1

being built up in successive layers, as is the case with the warp wind, the yarn is placed on the bobbin in coils, each succeeding coil being slightly higher on the bobbin. Thus, as shown in Fig. 2 (*b*), the first coil of yarn extends from j_1 to j_2, while the last coil extends from j_3 to j_4. The yarn

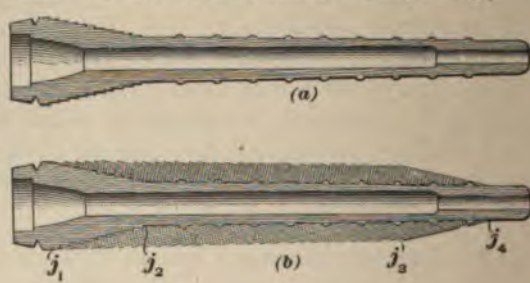


FIG. 2

in being unwound from such a bobbin must always be pulled from the top.

Mule yarn is always delivered from the mule in the shape of a **cop**, a view of which is given in Fig. 3. It consists of innumerable coils of yarn built up on a bare spindle

(or more commonly in America, on a short paper tube) in such a way as to form a cylinder coned at each end.

Warp yarn when spun on a frame should be spun warp-wind; that is, the traverse of the yarn should extend almost from top to bottom of the bobbin. If the yarn is spun on a mule, the warp cop should be as large as possible, since there is no reason to limit its size in order to get it into a shuttle, as would be the case with filling yarn. Warp yarn must ultimately be placed either on the loom beam to be woven or put up in the form of a bundle to be shipped from



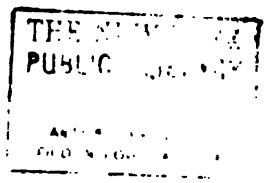
FIG. 3

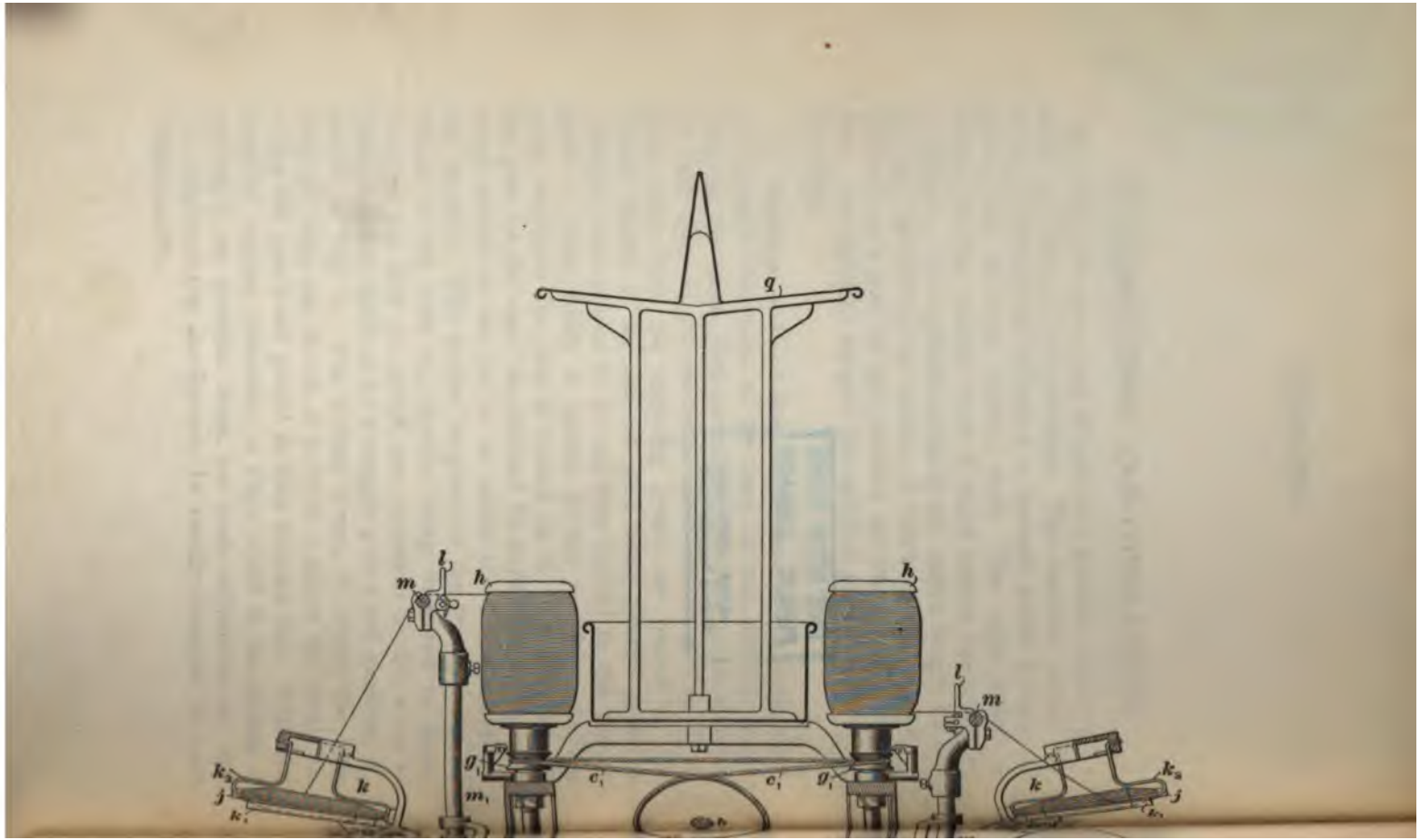
the mill where it is spun. In either case it must first be spooled, in order to obtain a greater length of yarn and thus facilitate later processes. If this were not done, the comparatively short length of yarn on one bobbin would necessitate constant piecing at the later processes and would consequently greatly lower the production. It may be said, then, that the object of the spooler is to place a suitable length of yarn on a spool, this yarn being taken from the bobbin or cop on which it has previously been wound at the spinning process. As has been said, warp yarn in almost every case comes to the spooler from the spinning frame and is on a bobbin having the warp wind. The spooler adapted to spooling the yarn when delivered in this manner will be the first described.

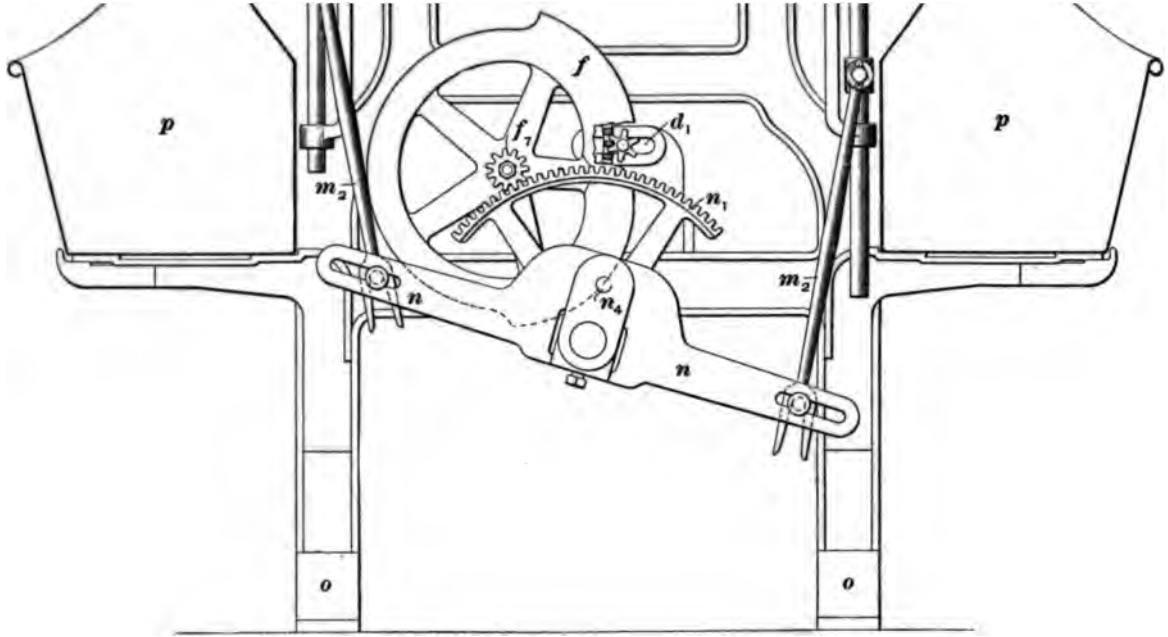
CONSTRUCTION AND OPERATION

3. Fig. 4 shows a view of part of a spooler, while Fig. 5 shows a section of the machine. The machine carries the usual tight-and-loose pulleys a, a_1 through which it receives power from the main driving shaft. The tight pulley is fastened to the cylinder shaft b, which carries the cylinder, or drum, c. The cylinder extends the entire length of the spooler, and drives by means of bands c_1 the whorls g, which form a part of the spindles on which the spools h rest. The spindles support the spools h on which the yarn is wound.

4. Passage of the Yarn.—As shown in Fig. 5, spoolers are so made that many of the parts on one side are duplicated on the other, thus permitting the yarn to be spooled on both sides of the machine. The bobbins j, Fig. 5, as they come from the spinning frame are placed in the bobbin holder k, the end of yarn being passed under a swinging arm similar to k_3 and then carried to the thread guide l, from which it passes to the spool h. As the spool revolves, the yarn is wound on it. The traverse of the yarn on the spool is obtained by imparting an up-and-down motion to the rail m on which the thread guides l are secured. This motion is given to the traverse rail by means of the rods m_1, motion being imparted to these rods by the rods m_2, which are connected to the arms n; these arms are acted on by a mangle gear f and quadrant n_1, shown in Fig. 5. The bobbin boxes, in which the bobbins are kept, are shown at p, while q shows the creels on which the spools are placed as they become full. With the make of spooler illustrated in Figs. 4 and 5, the stands o, on which the machine rests, are made adjustable, so that the height of the spooler may be readily changed to meet requirements.

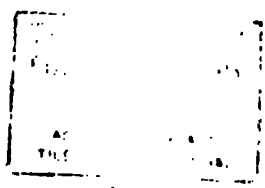

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FIG. 5



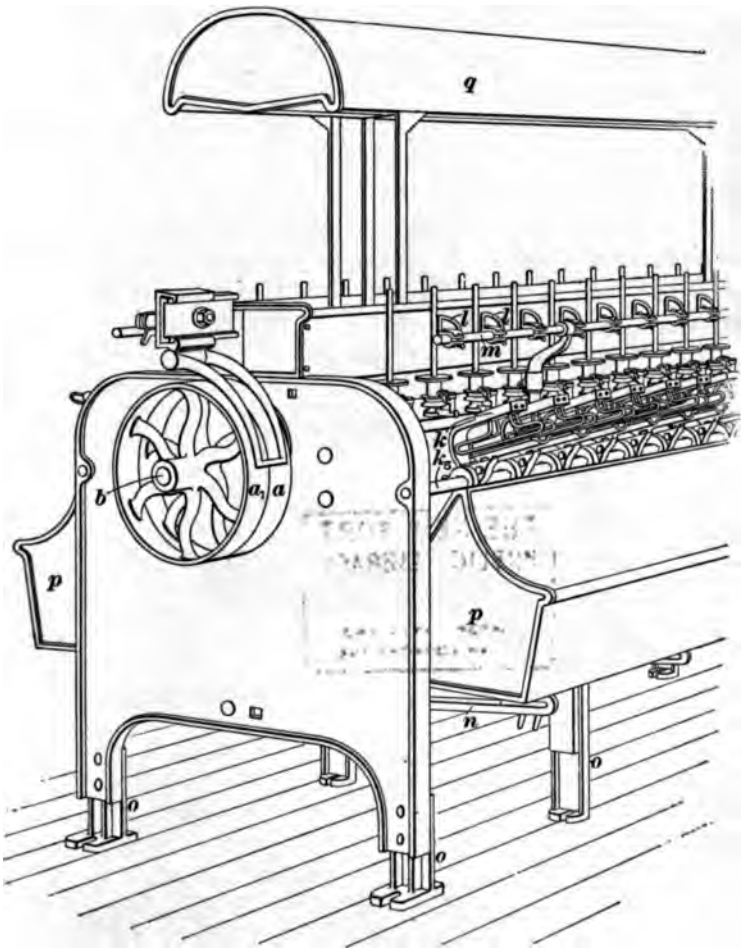


FIG. 4

DETAILS OF CONSTRUCTION

5. Having pointed out the principal parts of a spooler and indicated the passage of the yarn from the bobbin to the spool, the more essential parts will be given a fuller description. A spooler, however, cannot be said to be a very complicated machine, and since it does not have any direct effect

on the stock passing through it, there are no complicated settings to be made, as are met with in the majority of the other machines.

6. Bobbin Holder.—A common type of **bobbin holder** is shown in Fig. 6. It consists of a curved plate k, on which the bobbin rests. Above this plate projects an iron bracket k_2 carrying two curved wires k_3, k_4 that rest loosely in sockets and are thus allowed to move outwards or inwards. It is under one of these wires that the thread passes in going from the bobbin to the spool. The weight of the bobbin, resting on the curved plate, produces sufficient friction to keep the ends reasonably tight. As the bobbins decrease in

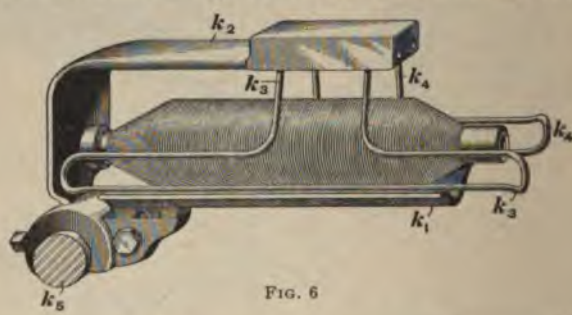


FIG. 6

weight, owing to the yarn being unwound from them, this friction will be lessened, but as more strain is put on the yarn when unwinding from a bobbin of small diameter, this is beneficial. The swinging wires also adjust themselves to give the proper angle for unwinding the thread, as required by the reduction of the diameter of the bobbin. The holders are attached by means of setscrews to a rod k_5 that extends along the sides of the machine. On most spoolers there are, in addition to the bobbin holders, spindles situated either at each end of the frame or at intervals along the frame, on which bobbins containing yarn too weak to stand the strain when unwinding from a bobbin holder may be placed and thus have the yarn taken from them.

7. Thread Guide.—Fig. 7 shows one type of **thread guide** found on spoolers. It consists of an upper plate l,

and lower plate l_3. The opening between these two plates can be made larger or smaller, according to the size of the yarn being run. The primary object of all thread guides is to guide the yarn from the bobbin to the spool, and yet they are used in a great many cases as a means of accomplishing other purposes. For instance, it is found in actual practice that a thread guide removes from the yarn a fractional percentage of refuse, such as leaf, dirt, and other foreign matter. Again, the thread guide, if the plates are set sufficiently close, will prevent large knots or bunches from passing on to the spool. As large knots and bunches in the yarn are a great drawback to good weaving, their removal at the spooler is to be recommended, but the practice, or rather the necessity, of performing such work at the spooler should not be encouraged, since this is something that should have been attended to at one of the earlier processes.

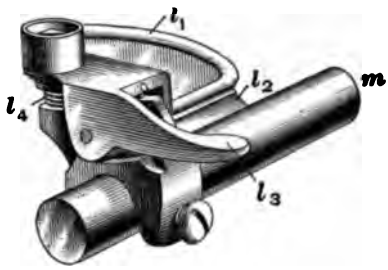


FIG. 7

By referring to Fig. 7 there will be noticed a thumb lever l_5. By pressing down on this lever the upper plate l_1 will be raised, thus giving sufficient space for cleaning any refuse that may have been collected by the guide during the passage of the yarn. The spring l_4 will return the plate to its position when the pressure is removed from the lever. The thread guide is setscrewed to the traverse rail m and is thus capable of being given any desired position in order to guide the yarn to the exact position it should occupy on the spool.

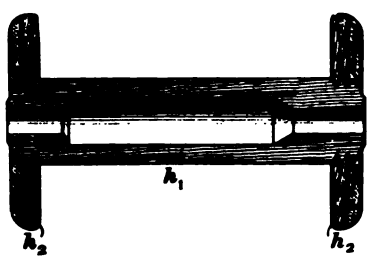


FIG. 8

8. The **spool**, as shown in Fig. 8, consists of a barrel h_1 with flanges, or heads, h_2 at each end. The heads of the spools are made of two pieces firmly glued together. By this means the tendency toward splitting is greatly reduced. The inner part of the barrel is hollowed out as much as possible without weakening the spool and thus a larger spool is obtained without bringing too great a weight on the yarn as it unwinds at the next process. The larger the spool can be made, the more yarn it will hold, and consequently the greater will be the production of the spooler; but there is a limit to the size of the spool, due to the fact that at the next process the yarn is obliged to turn the spool, and if too much tension is brought on it, it will break frequently and thus defeat the object of having a large spool. From this it will readily be apparent that the coarser the yarn, the larger will be the spool that can be used. Good sizes of spools for different counts of yarn are as follows:

TABLE I

Counts	Length of Traverse Inches	Diameter of Head Inches
8s to 16s	6	5
18s to 34s	5	4
36s to 54s	$4\frac{1}{2}$	$3\frac{1}{2}$
56s to 80s	$3\frac{1}{2}$	$3\frac{1}{4}$
90s to 100s	3	$2\frac{3}{4}$

9. The **spindle** used on a spooler consists of the blade g_2, Fig. 9 (*a*) and (*b*), supported by the base g_3, in which it revolves. The blade carries the whorl g_1, around which the band from the cylinder passes, and by this means the spindle is driven. The bottom of the spool rests on g_4 and is revolved by the spindle by means of its own weight, there being nothing to attach the spool to the spindle. The spindle shown in this illustration is known as the **single-rail spindle**; that is, it is supported by only one rail, to

which it is attached by means of the set nut g_5, the rail coming between the set nut and the part g_4 of the base g_3. The oil tube for oiling the spindle is shown at g_7. The cap g_8 prevents dirt and dust from entering the tube, and

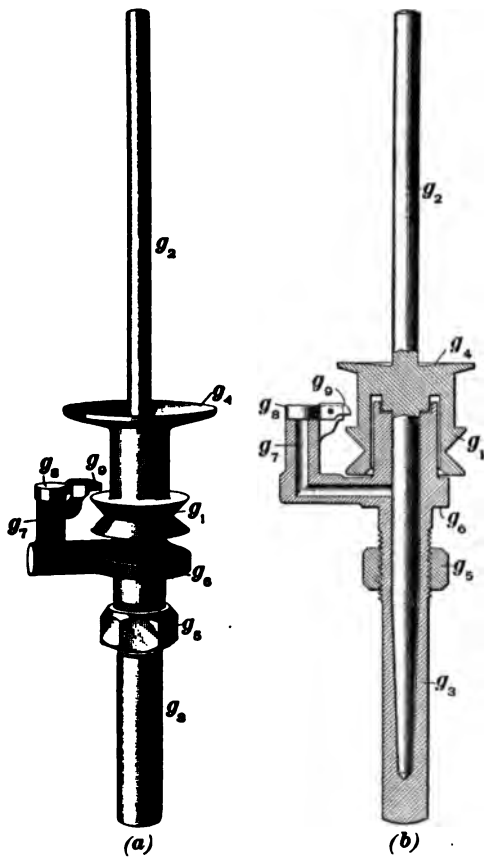


FIG. 9

also, by means of the projection g_6, holds the blade of the spindle in place.

10. Banding the Spindles. — Spooler spindles are banded in several ways, but the most popular method is to have one band for two spindles, one on each side of the

frame but not opposite to each other. For example, the band driving the first spindle on one side drives the second on the other side, and the band driving the second on one side drives the third on the other side, and so on. The bands are arranged in this manner in order that no two parts of one band shall be continually rubbing together.

After banding the spindles as just described, it will be found that the first spindle on one side and the last spindle on the other side are not provided for. To overcome this difficulty, one spindle on each side of the frame carries a

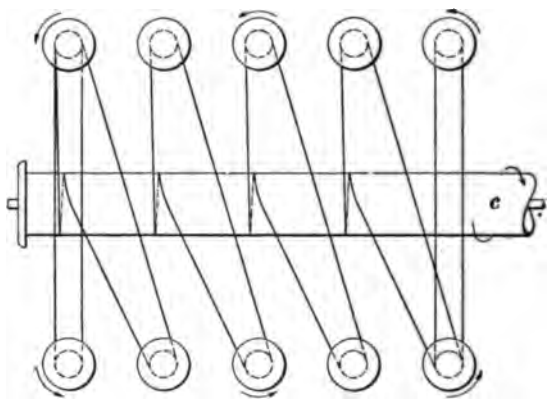


FIG. 10

double whorl, and consequently two bands. This method of banding is clearly shown in Fig. 10, where five spindles on each side of the frame are shown; *c* shows the cylinder of the spooler, around which the bands pass and thus receive their power. In some cases when spindles are banded in the manner just described, instead of providing spindles with a double whorl, the last band at each end of the frame will drive three spindles instead of two.

11. Another arrangement of banding the spindles is shown in Fig. 11. In this case one band is made to drive twelve spindles, and on this account is not so frequently used, since every time a band breaks it necessitates the stopping of twelve spindles. Another defect of this method is

that on some spindles the band is in contact with only about one-quarter of the circumference of the whorl, while on others it is in contact with one-half of the circumference, thus tending toward irregular speeds of the spindles.

The arrangement of banding the spindles that is illustrated in Fig. 11 can, of course, be extended to cover any even number of spindles within reason. Almost all, however, are arranged to drive either four, six, eight, ten, or twelve spindles.

Spooler spindles should be banded in such a manner that

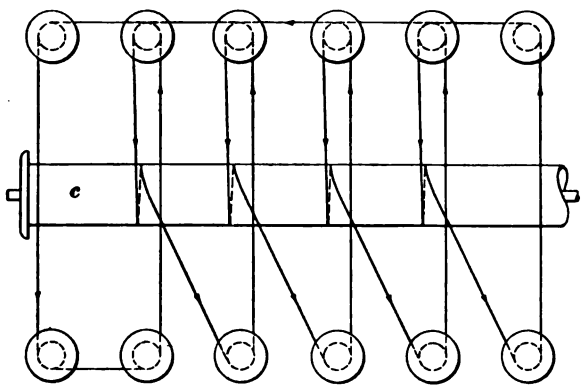


FIG. 11

they will revolve in the direction opposite to that of the hands of a watch, thus causing the ends when being wound to pass to the right-hand side of the spool.

BUILDER MOTIONS

12. Mangle Gears.—The yarn in being wound on the spool is given a traverse by means of the thread guide being attached to the traverse rail, this rail receiving an up-and-down motion while the spool revolves continually in the same plane. In winding the yarn from the bobbin to the spool there are two objects that must be attained: (1) The yarn must be wound from the bottom to the top of the spool, where it reverses and is wound from top to bottom,

reversing again at this point, and so on, each layer covering the preceding one; (2) the yarn should be wound on the spool in such a manner that the full spool will be larger at its center than at either of its ends, since a spool with the yarn wound in this manner not only holds more but also unwinds better at the next process. Both of these objects are attained by means of what is known as the **mangle**

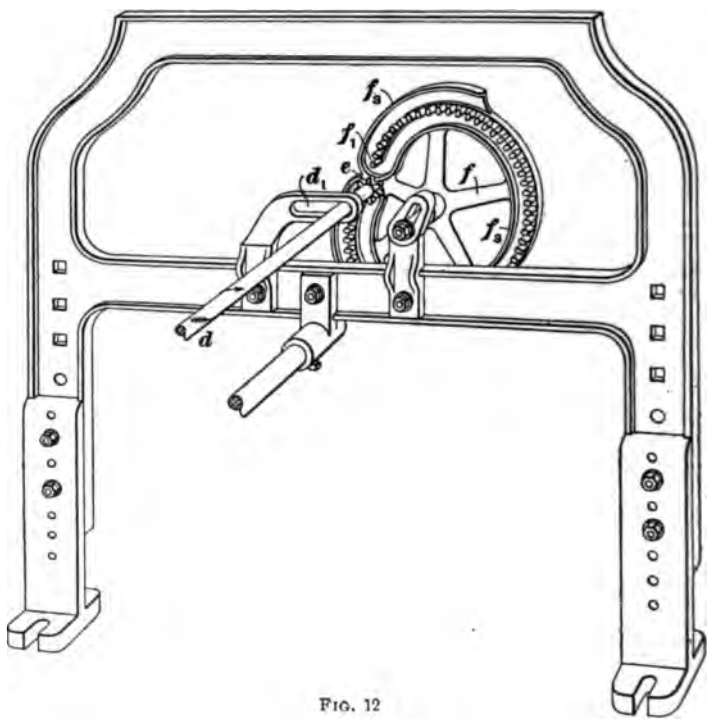


FIG. 12

gear and its connections. Fig. 12 is a view of these parts, an end view of the same being shown in Fig. 14, while Fig. 13 shows the mangle gear alone.

Rods m_1, Figs. 5 and 14, known as the lifting rods, are situated at regular intervals on each side of the frame. These rods slide up and down in brackets, and, being connected to the traverse rail, which carries the thread guides,

the latter move simultaneously up or down. Attached at the middle of each lifting rod is a rod m, that is connected to adjustable studs n, in the lever n. Extending along the center of the frame and directly under the cylinder is the shaft d, Fig. 12, which is driven from the cylinder shaft by means of a belt. At the end of this shaft, opposite to the driving end, is the gear e that drives the mangle gear f.

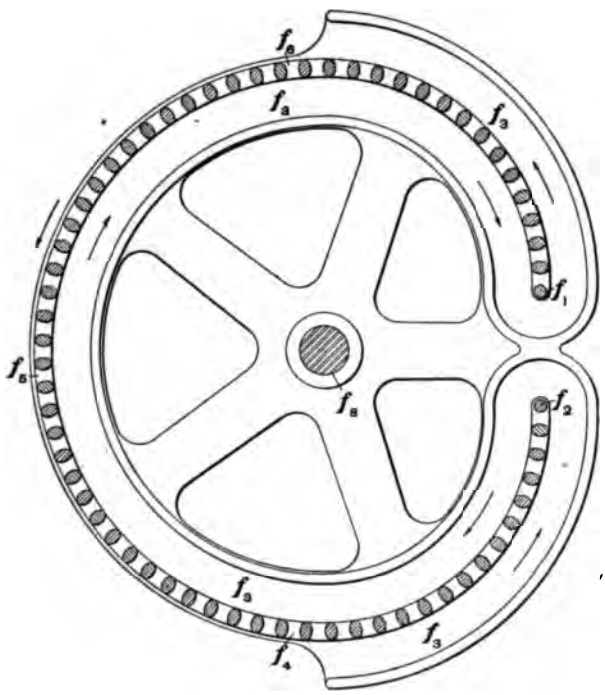


FIG. 13

13. Reference is now made to Fig. 13, which shows the mangle gear alone in cross-section. This gear is composed of two rings joined together by pins that form teeth. By this means, the pinion gear engaging with the mangle wheel can drive it either from the outside or the inside of the teeth. It will be noticed that the teeth of the mangle gear end at the points f_1 and f_2. This is to allow the pinion gear engaging

with the teeth to pass from the outside to the inside, and vice versa. Supposing the pinion to be on the outside of the mangle gear, it drives this gear around until the small opening at f_1 is reached, when it slips to the inside of the mangle gear and continues to turn it, but in the opposite direction. This continues until the opening at f_2 is reached, when the pinion passes to the outside and again reverses the direction of motion of the mangle gear.

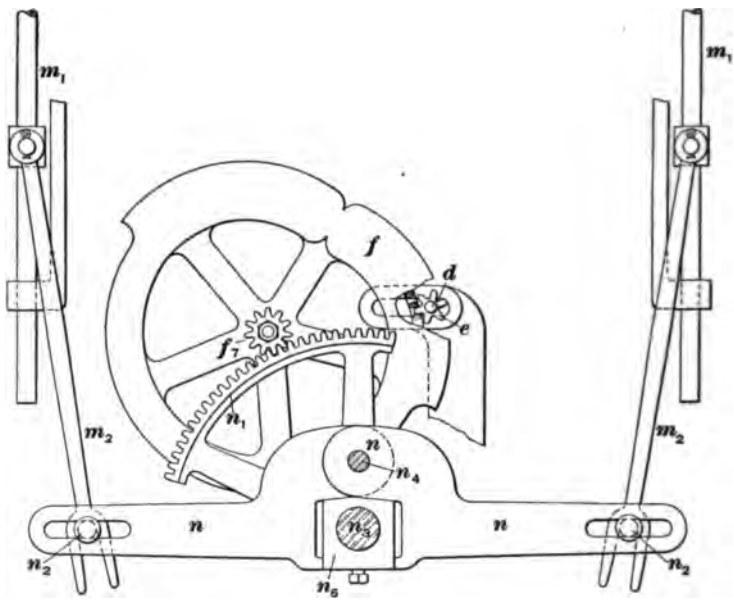


FIG. 14

Two points should be noted here: (1) As the mangle gear simply revolves without having any vertical or lateral movement, then the pinion must be provided with some such motion in order to allow it to pass from one side of the mangle gear to the other, since one of the two gears must change its relative position. It is made possible for the pinion gear to move back and forth by means of the shaft on which it is placed being held in a bearing d_1, Fig. 12, sufficiently wide to allow the required lateral movement.

(2) Since the pinion gear is not held firmly in one position by the shaft on which it is placed, some other provision must be made by means of which it will be held in contact with the teeth of the mangle gear at all times. This is accomplished as follows: When the pinion is engaging with the outside of the teeth from the point f_4 through f_5 to f_6, the shaft has been moved until it is being pressed against the extreme side of its bearing, and since it cannot be moved any farther in that direction, the teeth of the pinion must remain in gear with the mangle wheel. After the pinion has passed the point f_6, on the outside of the teeth, and until it again reaches the point f_4, on the outside of the teeth, it is held in gear with the mangle wheel by means of the end of the shaft projecting beyond the gear and thereby coming in contact with outer and inner guides f_3 with which the mangle gear is provided.

14. Reference is now made to Fig. 14, which gives an end view of these different parts. On the hub of the mangle gear is the gear f_7, which engages with the teeth in a quadrant n_1. The quadrant is fast to the shaft n_2, on which are also situated the levers n. The shaft n_2 extends the whole length of the spooler, and has at intervals other levers corresponding with n and other rods corresponding with m_2, m_1. As the mangle gear is having its direction of motion continually reversed, the quadrant also keeps reversing and gives an alternating up-and-down motion to the arms of the lever n and the other levers corresponding with it, this motion being also imparted to the lifting rods m_1 by means of the rods m_2. The lifting rods are so adjusted that when the rods are up on one side of the frame they are down on the other, so that one side tends to balance the other and thereby lessens the amount of power necessary to move the traverse rail.

15. Build of the Spool.—As previously referred to, it is desirable to give a barrel shape to the spools in order that more yarn may be put on each spool. In order to give this barrel shape to the spool, the traverse rail, and consequently

the thread guides, move more slowly along the central parts of the spool than at the ends. At the latter points a quick approach to and return from the head of the spool is desired. If the mangle gear were circular and the speed of the pinion gear remained constant, the speed of the traverse rail would be constant on both the upward and downward traverse and at every part of each traverse, thus producing a spool no larger in diameter at one place than at another. The manner in which the desired result is attained is to have the mangle gear eccentric, as shown in Fig. 13, the center of the stud f_5, on which the mangle is mounted, being nearer to the points f_1 and f_2 than it is to any one of the points f_4, f_3, or f_6. In fact, the distance from the center to the points f_1 and f_2 is only 4 inches, while the distance from f_5 to f_4, f_3, or f_6 is 6 inches. Consequently, when the pinion gear is in gear with the mangle wheel at the points f_1 or f_2, it may be said to be driving a gear 8 inches in diameter, while on the other hand, when it is in gear at the points f_4, f_3, or f_6, it is the same as driving a gear 12 inches in diameter, and consequently at a reduced speed. The mangle gear is so set that the traverse rail on one side will just reach the top of its traverse when the pinion is at the point f_1, and the bottom of the traverse when the pinion is at the point f_2. The conditions on the other side of the frame will, of course, be the exact reverse of this; consequently, the thread guides start quickly at the top of the spool and gradually slacken their speed as they approach the center, increasing their speed again just before reaching the bottom of the spool. After they have reversed and traveled a short distance upwards, the speed is again slackened until they have passed the center, when it is increased for the approach to the top of the spool.

16. Another arrangement for obtaining the traverse of the thread guides and the desired build of the spool is shown in Fig. 15. In this arrangement the mangle gear and lifting rods are employed, as in the motion previously described. The method, however, of driving the mangle gear and raising and lowering the lifting rod differs slightly. Referring to

Fig. 15, the pinion shaft r is driven by a chain r_1 from the cylinder shaft. The bearing r_2 of the shaft r is so arranged that the shaft is allowed a vertical movement instead of a lateral movement, as in the previous case. The mangle gear f is driven by a pinion gear on the end of the shaft r, and being fast to the shaft s, it in turn drives the gear t by means of another gear on this end of the shaft. Fast to the shaft carrying the gear t is the segment arm t_1 carrying the

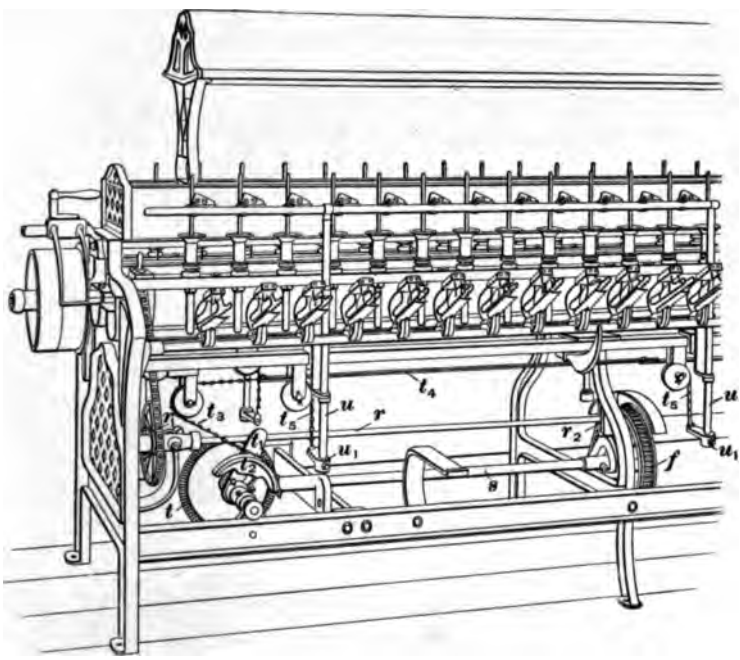


FIG. 15

segment t_2. Connected to the segment is the chain t_3 that operates the rod t_4 and chains t_5, the chains t_5 being connected to the lifting-rod dogs u_1 attached to the lifting rods u. Since the mangle gear is driven first in one direction and then in the other by the pinion gear, the gear t will also reverse its direction of motion at regular intervals. This will impart a swinging motion to the segment arm t_1 and

also to the segment t_1, resulting in the chain t, being alternately brought down and let out. As this chain is brought down by the action of the segment it will raise the traverse rail through connections referred to, while on the other hand, when the chain is let out, the rail, due to its own weight, will drop. Since the mangle gear is constructed on the same principle as the one previously described, the desired results will be obtained.

17. Winding From Cops or Bobbins Having a Filling Wind.—In cases where the yarn is to be wound on to

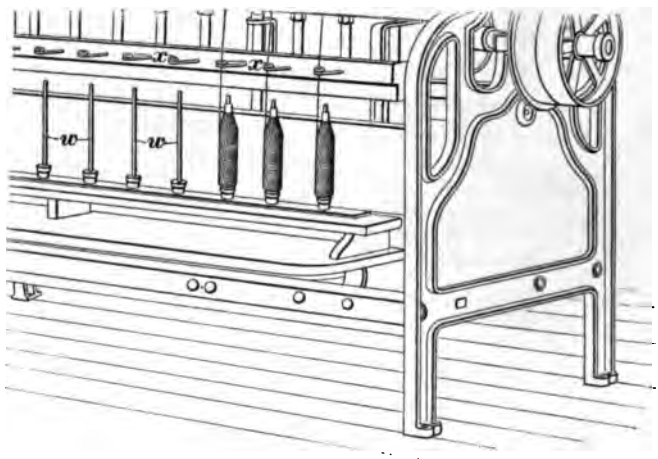


FIG. 16

spools from cops or from bobbins with a filling wind, a arrangement differing from any previously shown must b adopted for holding the cops or bobbins, since a filling win differs entirely from the ordinary warp wind, the yarn in th former case being built up from the bottom, while in th latter case it is placed on the bobbin in layers one abov the other. Thus, in one case, the yarn must be pulled o at the nose, while in the other the yarn is unwound from th side. Fig. 16 shows an arrangement suitable for holdin the cops or filling-wind bobbins when the yarn is bein spooled. The cops or bobbins are placed on the spindles

and the yarn carried through the guides x to the thread guide on the traverse rail and then to the spool. In this manner the yarn is pulled directly from the nose of the cop or bobbin, which method must always be adopted in order to run the yarn at all successfully. In most cases when spooling yarn that has a filling wind, the yarn has to be run over a friction flannel situated between the cops and spools, in order to give the yarn sufficient tension to be wound on the spool in a compact form.

18. Safety Device.—With the motion shown in Fig. 14, the levers n are so constructed that, should any obstruction prevent their lowering, they will simply be held in one position and the yarn will be wound on the spool at one place. Referring to this figure, it will be seen that the arms swing on the stud n_4. Fastened to the shaft n_3, on which is placed the quadrant, is the casting n_5, so shaped that its lower edge, pressing against the lever, will lift it when the quadrant is turned. For example, suppose the quadrant is turning to the left; then the lower right-hand corner of the casting n_5 will press against the arm n on the right-hand side and raise the lifting rods on that side of the frame. When the quadrant swings in the other direction, the lever will drop on account of its own weight and the weight of the lifting rods and traverse rail resting on it; but the casting n_5 is not acting on it in any manner, excepting to allow the lever to fall gradually; consequently, it is capable of being held up by any obstruction. The stud n_1, Fig. 14, also works loosely in the slot in the rod m_3 and is a further precaution against the breaking of any parts should the traverse rail or the rod m_1 be prevented from dropping. With the motion shown in Fig. 15, the quadrant does not, of course, have any positive action on the rods when they are dropping, since it simply allows the chain to run out and thus permits the rods to drop by means of their own weight.

19. Dimensions of Spoolers.—Spoolers are constructed in various sizes, containing usually not less than 30 and not more than 80 spindles on each side. Spoolers are

spoken of not only by their length and by the size of the spool they use, but also by the gauge, that is, the distance from the center of one spindle to the center of the next. A common gauge is $4\frac{3}{4}$ inches, this of course being reduced for small spools used for spooling fine yarns and increased for large spools in the case of running coarse yarns. The length of a spooler containing 100 spindles with $4\frac{3}{4}$-inch gauge is 21 feet, 3 inches; its width is 4 feet.

SETTINGS

20. Setting the Parts of the Builder Motion.—To set the mangle-gear arrangement, shown in Figs. 5 and 14, have the pinion gear just at the point of reversing the mangle gear; then find the difference between the number of teeth on the segment and on the stud gear and set the stud gear so that it will be half this number of teeth away from the end of the segment. For example, if the segment contains 28 teeth and the gear meshing with it has 20 teeth, then when the mangle gear is at the point of reversing, have the gear on the stud 4 teeth from the end of the segment. $28 - 20 = 8$. $8 \div 2 = 4$. At this point the top of the traverse rail on one side of the spooler should be about $\frac{1}{16}$ inch below the top heads of the spools, while the top of the traverse rail on the other side should be the same distance above the bottom heads of the spools on that side of the machine.

21. Regulating the Traverse.—The gear meshing with the segment is known as the **change gear,** and it is this gear that is altered when a change in the traverse is desired. As previously stated, different counts of yarn require different sizes of spools; consequently, whenever a different class of work is started, this gear must be changed in order to obtain the required traverse. A larger gear drives the quadrant more quickly, and consequently makes it travel a greater distance while the mangle gear is making one revolution. This gives a longer traverse of the traverse rail. A smaller gear has, of course, the opposite effect. In

case the change gear does not give the exact traverse required, any slight change may be obtained by moving the studs n_1, Fig. 14, inwards or outwards. Moving them inwards gives the lever n less leverage and consequently shortens the traverse. By this method of changing the traverse, the traverse on one side may be altered independently of that on the other, which cannot be done by changing the change gear.

22. Regulating the Point at Which the Traverse Rail Reverses.—Another adjustment, but one that alters only the point at which the rail reverses without altering the traverse, can be made by dropping or raising the lifting rods. If, for example, the traverse rail is a little too high at both the top and bottom points at which it reverses, then the rods may be dropped until the traverse rail assumes its correct position. Care should be taken, however, to have the traverse rails perfectly horizontal and the studs in the slots of the lever n all set at the same point on one side of the frame.

23. To set the builder motion shown in Fig. 15, turn the gears until the pinion gear is at the central part of the mangle gear. When in this position, the top of the traverse rail should be in the exact center of the spool and the chain attached to the segment should leave the segment at exactly its central position. At the points of reversing, the top of the traverse rail on one side should have the same relative position to the top heads of the spools that the top of the traverse rail on the other side has to the bottom heads of the spools. With this motion the gear driving the gear t is the change gear; the larger the gear, the longer will be the traverse.

Another adjustment of the traverse may be made by means of the segment t_1, which is attached to the segment arm t, by a bolt in such a manner that it may be moved either toward or away from the shaft carrying the segment arm. By moving the segment toward the shaft, the traverse is shortened. By moving the segment away from the shaft, the traverse is lengthened. If the length of the traverse is

correct but the rail does not reverse at exactly the right point, this may be adjusted by altering the point at which the dog u_1 is setscrewed to the lifting rod u. Care should be taken, however, to have the traverse rail perfectly level. The thread guides are adjustable on the traverse rail, and in some cases their position is changed in order that the yarn may be wound correctly on the spool. Sometimes the spools at one end of the frame are correctly wound while those at the other end are wrong. In such cases the lifting rods that support the traverse rail are not sufficiently well lubricated or are sticking for some other reasons.

The upper and lower plates of each thread guide should be set at such a distance apart that the yarn will just pass through without chafing. It is a good plan to use No. 7 or No. 9 card gauge to set these on fine yarns and No. 11 on coarse yarns, or even No. 7 and No. 9 together, equaling No. 16, on very coarse yarns. The settings of these plates should be looked over frequently.

MANAGEMENT

24. Properly Shaped Spools.—The faults caused at the spooler are generally in connection with the shape of the spool. If the traverse given to the thread guides is not sufficiently great, soft places at both the top and bottom of the spools will result. If the length of the traverse is correct but so set that it runs up too high, a hard place is formed at the top of the spool and a soft place at the bottom. If the length of traverse is correct but runs down too far, then the opposite effect is produced. Care should always be taken to have the bearings of the lifting rods well lubricated, since if these are sticking, the spools will not be filled correctly.

25. Speed.—It is not desirable to run spoolers too fast, since slower speeds tend to maintain the strength of the yarn, leaving it more elastic and causing fewer knots in the warp. It is much better to have a few extra spoolers

than to strain the yarn by endeavoring to run it through fewer spoolers.

26. Number of Spindles.—Where it is possible to be arranged, it is a good plan to have the number of spindles on both sides of the spooler just equal to the number of spindles on one side of the spinning frame. By this means one doffing of a spinning frame will supply two rounds to the spooler, and if all the spindles are kept running in both frames, one doff will be completely used before another one is started on. In this manner bad bobbins or poor doffings may be traced more readily.

27. Marking Spools.—It is well to have the spooler tenders mark with chalk all spools that they fill, so that the counts of the yarn may be easily ascertained. This prevents the mixing of yarn of different counts. Some mills use spools with different colored heads, one color always being used for a certain count. This answers the purpose better. It may also be often found advisable to have each spooler tender mark her number on the yarn on each spool she fills, in order to readily trace each tender's work.

28. Waste.—It is necessary for the overseer of a spooling room to see that the bobbins are emptied of yarn before being returned to the spinning room, and also that no yarn is thrown on the floor, but retained to be sold as waste. With a good quality of yarn the percentage of loss through waste ought not to exceed from $\frac{1}{4}$ to $\frac{1}{2}$ of 1 per cent. This is with the yarn wound on bobbins. When the yarn comes to the spooler on cops, the waste amounts to $1\frac{1}{2}$ per cent.

29. Method of Paying Spooler Tenders.—Spooler tenders are paid, as a rule, by the number of boxes that they spool; that is, the number of doffings of the spinning frame that are sent to them. In some mills spooler tenders are paid by the day. In paying the spooler tender by the box, the amount of yarn contained in one box is ascertained and the price for spooling a box is calculated at so much per pound. A higher rate is paid per pound for fine yarns

than for coarse yarns, as it takes a longer time to spool a pound of fine yarn than to spool a pound of coarse yarn. In order to fix the rates, the theoretical production of the spooler is found by calculation and the price fixed so as to enable the spooler tender to earn usually about $6 per week, although this varies in different districts.

30. Knot Tying.—One of the greatest difficulties met with at the spooler is **knot tying.** As spooler tenders are usually paid on the piece-work plan, they are therefore generally anxious to turn out as many spools as possible; consequently, whenever an end breaks, the tender ties it up as rapidly as possible, in many cases making a large knot and leaving long, loose ends. When knots of this character come to the weaving process, they are sure to break the end containing the knot, and in many cases will also succeed in breaking out many others, causing a much longer and more serious delay at the loom than would have been required at the spooler. Overseers of spooling rooms should always require the spooler tenders to tie as small and neat a knot as possible, a weaver's knot being preferable in every respect.

Several inventions known as *knot tiers* have been patented, their object being to do away with the evils just referred to. It is claimed by the makers that by using these and thus tying the knots mechanically, large knots and long, loose ends are entirely done away with. In some cases one knot tier serves for one side of the machine; it is attached to an iron rod behind the spools and is capable of being moved along this rod to any position desired. In other cases the knot tier serves for only one spool, there being one for each spool on the machine; while in still other cases the knot tier is so constructed that it can be carried around by the spooler tender and taken to any spool on the frame as needed.

31. The Barber Knotter.—A knot tier that is meeting with considerable favor is illustrated in Fig. 17 and is known as the **Barber knotter.** It is worn on the left hand of the operator, with the thumb resting at *y*. The ends, one from the spool and one from the bobbin, are drawn over the top

of the machine, as shown in the illustration. By pressing down on y with the thumb, the clamp bars y_1 are caused to revolve, and in doing so form a loop in the yarn, cut the ends, and then draw the severed ends through the loop, thus making a knot. The bar y_3 is then made to slide out and, by pressing against y_3, holds the yarn at the point y_4, when the parts y_3 and y_3 move away from the side of the machine; since the yarn is held securely at the point y_4 and also by the clamp bars y_1, it will be drawn tight, thus securely fastening the knot that has previously been tied. It is claimed that by having the spooler tenders use this knotter, not only will the production be increased at the spooler, but the capacity of the weave room will also be increased, due to the knots being tight and having the ends short and perfectly trimmed.



FIG. 17

CALCULATIONS

SPEED CALCULATIONS

32. There are not very many calculations connected with the spooler, the spindle speed, change gear, and production covering about all.

Figuring the speed of the spindles is a simple calculation to which the ordinary rules for this class of examples will be found to apply.

EXAMPLE 1.—The main shaft of a room runs 200 revolutions per minute and carries an 11-inch pulley driving a 10-inch pulley on a spooler. The cylinder on the spooler is 6 inches in diameter, and the

whorl of the spindle is $1\frac{1}{2}$ inches in diameter. What is the speed of the spindle?

SOLUTION.— $\frac{200 \times 11 \times 6}{10 \times 1.5} = 880$ rev. per min. Ans.

One point should be noted in this connection—that the true diameter of the whorl cannot correctly be considered the actual diameter on which the band runs, since the band, being round, is of a measurable diameter, and therefore its diameter should be added to that of both the drum and whorl in order that more accurate results may be obtained.

EXAMPLE 2.—Suppose that in the example just stated the band is $\frac{3}{16}$ inch in diameter; then add this thickness to the diameters of the drum and whorl.

SOLUTION.— $\frac{200 \times 11 \times 6\frac{3}{16}}{10 \times 1\frac{11}{16}} = 806.66$ rev. per min. Ans.

A still more accurate method would be to turn the drum around once by hand and count the number of revolutions that the spindles make during this time. Then, by figuring the speed of the drum, the speed of the spindles may be readily ascertained.

CHANGE GEAR

33. In figuring the change gear for a spooler, the length of the traverse is in direct proportion to the size of the gear; consequently, if the size of the gear and the length of traverse it gives are known, the desired gear for any traverse, or the traverse that any size gear will give, may be easily found.

To find the gear required to give a desired length of traverse when the gear being run and the length of traverse it gives are known:

Rule I.—*Multiply the traverse gear being used by the length of traverse desired and divide the result by the length of traverse being run.*

EXAMPLE 1.—An 11-tooth gear is being used and gives a $5\frac{1}{2}$-inch traverse. What gear will be required for a $4\frac{1}{2}$-inch traverse?

SOLUTION.— $\frac{11 \times 4\frac{1}{2}}{5\frac{1}{2}} = 9$-tooth gear. Ans.

To find the length of traverse that a certain gear will give when the gear being used and the length of traverse it gives are known:

Rule II.—*Multiply the length of traverse being run by the gear to be used and divide this result by the gear being used.*

EXAMPLE 2.—An 11-tooth gear gives a 5½-inch traverse. What traverse will a 9-tooth gear give?

SOLUTION.— $\frac{5\frac{1}{2} \times 9}{11} = 4\frac{1}{2}''$ traverse. Ans

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PRODUCTION

34. When figuring the production of a spooler, the following will prove of advantage: The production of a spooler with a spindle speed of 750 revolutions per minute has been found from actual practice to be 90 hanks per spindle in 10 hours. From this the number of pounds or ounces per spindle may be figured, since hanks divided by counts equals pounds. For example, suppose the spooler is running 30s, then the production per spindle will be 90 ÷ 30, or 3 pounds.

In case the spindle speed differs from that stated above, the production may be figured by proportion.

EXAMPLE.—What would be the production per spindle in 10 hours of a spooler with a spindle speed of 900 revolutions per minute spooling 80s?

SOLUTION.—
$$750 : 900 = 90 : x$$
$$900 \times 90 = 81{,}000$$
$$81{,}000 \div 750 = 108 \text{ hanks}$$
$$108 \div 80 = 1.35 \text{ lb. Ans.}$$

BEAM WARPERS

PRINCIPAL PARTS OF WARPERS

ENTWISTLE WARPER

1. Introductory.—Warping, the process that follows spooling, is an important feature of the ordinary method of cotton-warp preparation. As the yarn comes from the spooler, it is taken to the machine known as the **warper,** the object of which is to unwind the yarn from a large number of spools and place it in an even sheet on a beam, which is a cylinder of suitable length with heads at each end. The yarn is then in a more suitable shape for handling in the future processes. Warping is divided into several different classes according to the manner in which the yarn is treated. The class being dealt with at present is known as *beam warping*, from the fact that the yarn as it is unwound from the spools is wound on a beam.

2. The plan on which the warper for beam warping is constructed and operated is simple, as it consists of arranging spools of yarn in a creel so that they revolve with the least possible resistance, while the yarn that they contain is wound on a roll, or beam, rotated by contact with a revolving cylinder. As warpers do not vary much in their general construction, a description of the **Entwistle** will serve as an explanation of all. The special devices will be described later. Fig. 1 shows the creel and warper as they appear when in operation, while Fig. 2 shows a section of the parts

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of the warper with which the yarn comes in contact when passing from the creel to the beam. Referring to these figures, *a* shows the creel that holds the spools *b*. The ends are gathered from the spools and passed between the guide rods c, c_1; they then pass through the expansion comb *d*, under the drop roll *e*, over the guide roll *f*, through the drop wires g, g_1, through the expansion comb d_1, over the measuring roll *h*, and then to the beam *k*, on which they are wound in an even sheet.

3. Warper Creels.—The essential features of all creels are to have them so constructed that the different ends will be unwound from the spools without snarling; that the pull on the yarn will be as straight as possible; and that there will be the least possible strain on the yarn. The form most generally used at the present time is known as the **V** creel, shown in Fig. 3. It is so constructed that it holds the spools



FIG. 3

in tiers; the end from any spool can pass to the warper in as nearly a straight line as possible without rubbing against any other spool. The creels are made of wood but have metal or glass rods on the outside strips to reduce the friction on the threads as much as possible. The ends of the wooden skewers passing through the spools rest in metal or

glass steps inserted in or attached to the side of the framework; by this method the least possible resistance to the turning of the spools is obtained. A glass step is shown in Fig. 4. Creels are usually screwed to the floor, but the distance between the strips supporting the spools can in some cases be changed to meet the requirements of different sized spools. Creels generally have a capacity of 15 spools in a vertical row and 17 in a horizontal row; the creel, consequently, holds 510 spools—255 on each side. Different sizes are, of course, met with, creels with a capacity of 780 spools being sometimes used.

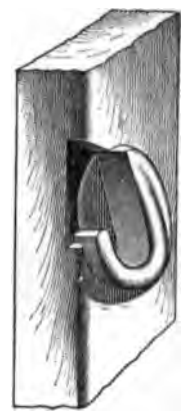


FIG. 4

In passing the ends from the creel to the warper, those from the front of the creel come to the center of the comb *d*, Fig. 2, while those at the right hand of the creel at the back come to the right-hand side of the comb and those from the left of the creel at the back come to the left-hand side of the comb. The first end taken from either side of the creel should be the one from the top spool in the front row on that side, and the ends should then be taken in regular order downwards. When the ends have been taken from the front row of spools in this manner, the second row should be treated in the same way, and so on until the ends from all the spools in the creel have been taken to the warper.

The V creel is not the only style used in connection with warpers, as spools are sometimes placed on an almost horizontal creel immediately behind the machine and also on a vertical creel behind this, while for a small number of ends a curved framework is sometimes used.

4. Expansion Combs.—The first important part of the warper with which the yarn comes into contact as it passes from the creel is the **expansion comb** *d*, Fig. 2, shown alone in Fig. 5. It is constructed by inserting wire teeth d_1 through spiral springs d_2, which are held by the rods d_3. A

rod d_6 that passes through the springs d_3 is connected to a thin brass strap d_7 wound around a stud on the hand wheel d_8. These parts are duplicated at the other end of the comb. The tension on the springs d_3 may be increased or lessened by turning the hand wheel d_8, so that the spaces between the wire teeth may be enlarged or reduced, and the fineness of the comb regulated so as to uniformly distribute the sheet of yarn over the whole width of the machine irrespective of the number of ends being run. The center of an expansion comb is usually designated by having the central

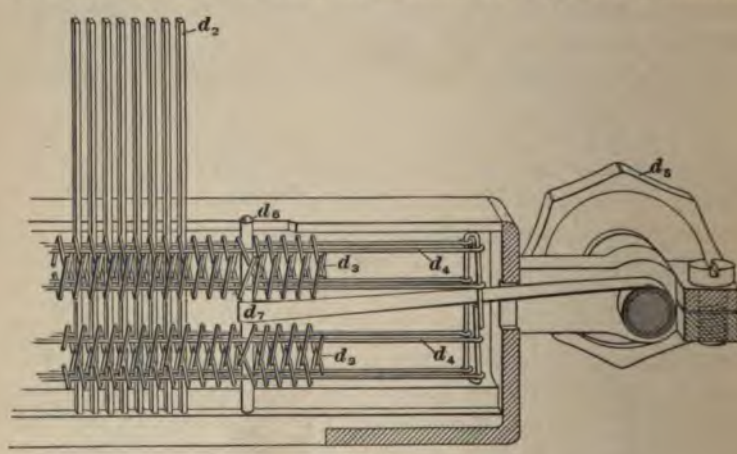


FIG. 5

tooth slightly shorter than the others, so as to readily show where to begin passing the ends through the comb when starting a new set of spools in a warper.

Fig. 2 shows two expansion combs d, d_1 on one warper. In some cases the teeth in the comb at the front of the machine are made of round wire.

5. Drop Roll.—Passing from the expansion comb, the yarn comes into contact with the **drop roll** e, Fig. 2, which takes up any slack yarn that may be let off by the spools and not taken up by the beam. When the warper is stopped for any cause, the momentum of the spools causes considerable yarn to be unwound, which, if not taken care of in some

manner, may become snarled and break when the warper is again started. The roll e is a brass roll having bearings that slide in almost vertical slots e_1 constructed in the inside of the frame. It is supported by the yarn alone, the tension of which is sufficient for this purpose except when the ends become slack owing to the warper being stopped; in such cases the roll drops in its guide slots, taking down the slack yarn and, as the yarn is supported on each side of the drop roll by the rods c_2, c_3, Fig. 2, 6 feet of slack yarn can be taken care of, although the roll drops only about 3 feet. It should be understood that, if a smaller amount of yarn is let off, the roll drops only far enough to take up the slack, when it is again supported by the tension of the yarn.

6. Stop-Motion.—The principal object of a warper is to wind on a beam an even sheet of yarn that consists of the same number of ends at all times. To aid in accomplishing this, all modern warpers are supplied with **stop-motions**, which stop the machine if a single end breaks while passing from the creel to the beam. They also lessen the cost of production by reducing the number of persons necessary to tend the machines, since one attendant is then able to operate from four to eight warpers.

The principle on which the stop-motion is constructed is that of having each end that passes from a spool to the beam threaded through a drop wire, which is either held upright or in some cases entirely suspended by the thread. In case any end breaks, the drop wire that it supports falls and, by suitable mechanism, shifts the belt to the loose pulley and stops the machine. The relative position that these drop wires g, g_1 occupy in the warper is shown in Fig. 2, while the mechanism of the stop-motion itself is shown in Fig. 6. The foot-board s_3, Fig. 6, is pressed by the operator when starting the machine; this turns the shaft s, to which is fastened the lever s_2 carrying the weight s_1; at the same time the rod s_4 is lowered until the notch s_6 drops below a hole in the casting s_5, when s_6 falls to the right and is held in this position, although the weight s_1 is constantly tending to raise the foot-board s_3

and the rod s_4. The cam-bowl r attached to the lever r_1 works in the revolving cam r_1. The rod r_3 being attached to the lever r_2, is given an up-and-down motion and slides in the bearing r_4; when in its normal position it just clears the casting x. At its upper end, r_3 supports the part v by means of a suitable projection. As r_3 is pushed up it takes with it v;

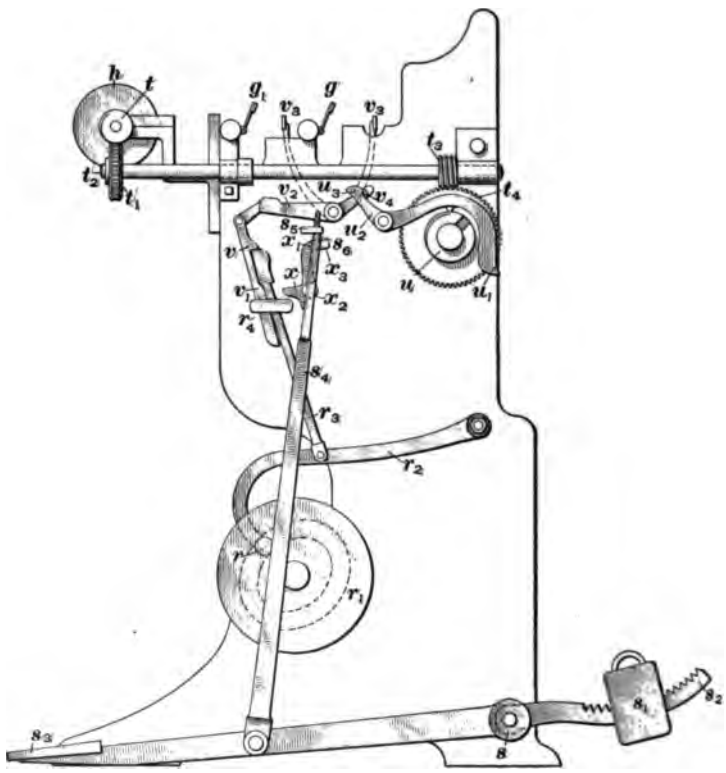


FIG. 6

when, however, it is brought down, it has no other effect on v than to allow it to fall by means of its own weight, which it does if it is not obstructed in any manner. The rod v_2, which works on a shaft on which are fastened the feelers v_3, is connected to v; consequently, as v is worked up and down, it gives an oscillating motion to the feelers v_3. The drop wires

are arranged in two rows, which economizes space, since if all the drop wires that are required for the number of ends run were placed on one bar, the space necessary would be considerably in excess of the space required for the ends.

In case any end from the creel breaks while passing to the beam, the drop wire through which it is threaded drops and lies in the path of one of the oscillating bars v_3, thus preventing v from dropping. Consequently, when the rod r_3 is brought down by the action of the cam r_1 and lever r_2, a shoulder on r_3 will come in contact with a shoulder on v at the point v_1. Since v cannot be pushed to the left because of the bearing r_4, the upper end of the rod r_3 will be pushed to the right and its notch will engage with the lever x, causing the upper end x_1 to be thrown to the left, as it swings about the point x_2. As x_1 is brought forwards, the projection x_3 engages with the rod s_4 and pushes it to the left far enough to allow the notch s_6 to be free of the casting s_5; this allows the weight s_1 to push up the foot-board s_2 and with it the rod s_4, shifting the belt to the loose pulley by the mechanism shown in Fig. 1, and stopping the machine. After the attendant has pieced the broken end, it is simply necessary to press down on the foot-board s_2, when the different parts will assume their former positions and the belt will be held on the tight pulley.

The manner in which the foot-board s_2 moves the belt from one pulley to another is shown in Fig. 1. At the driving side of the machine the foot-board is connected by two short arms to a stud that carries a lever s_7, which at its inner end supports a stud working in a slot in the casting s_8 that carries the belt shipper s_9. As the foot-board s_2 is pressed down, the inner end of the lever s_7, together with the stud that it carries, is raised. Owing to the inclined position of the slot in the casting s_8, the stud in rising will move this casting, together with the belt shipper s_9, to the left, shifting the belt from the loose pulley p_2 to either the slow-motion pulley p_1 or the tight pulley p, as may be desired. When the foot-board s_2 rises, the action of course will be opposite to that described and the belt will be carried to the loose pulley p_2.

In this warper, the drop wires are mounted on brass blocks, each of which contains four drop wires. In case any of the wires become damaged, it is possible to remove the blocks containing them by simply sliding them out at one side of the machine; the manner in which they are supported is shown at g_3, Fig. 2. When an end breaks and the drop wire falls, it rests on the horizontal rod g_2, Fig. 2, which brings it directly in the path of the oscillating bars. The arms j_1 support wires j_2 extending the whole length of the machine directly back of each row of drop wires. When the belt is shifted to the tight pulley, the rods j are turned sufficiently to bring the arms j_1, together with their wires j_2, low enough to allow the drop wire when it falls to come in the path of the oscillating bar. When, however, an end breaks and the machine is stopped, the mechanism that shifts the belt to the loose pulley causes the rods j to be turned and the rods j_2 to lift all the drop wires into the position that they assume when held upright by the threads passing through them. By this means the ends that are broken are easily rethreaded by the attendant when piecing up.

7. Measuring Motion.—As shown in Fig. 2, the yarn after passing through the drop wires of the stop-motion, next passes through the expansion comb d_1 and then over the *measuring roll* h, which is driven by the friction of the yarn; consequently, when it has made one revolution, a length of yarn equal to the circumference of the roll has been wound on the beam. The gearing by means of which the amount of yarn run is recorded is shown in Figs. 6 and 7. On the end of the measuring roll h,

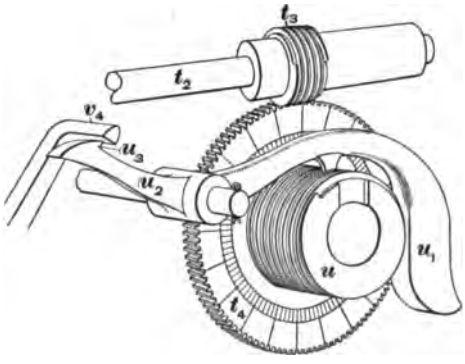


FIG. 7

which is 12 inches in circumference, is a single-threaded worm t that gears with the worm-gear t_1 on the shaft t_2; on the other end of this shaft is the single-threaded worm t_3 gearing with the worm-gear t_4 on what is known as the *measuring disk*. This disk carries a barrel u that contains spiral grooves in which sets a projection on the finger u_1; the gears in this train are as follows: t, single-threaded worm; t_1, 90 teeth; t_3, single-threaded worm; t_4, 100 teeth. By this arrangement one revolution of the barrel u represents 3,000 yards run on the beam. In warping yarn, 3,000 yards is spoken of as one *wrap;* thus, it is frequently stated that one, two, or three wraps have been run, indicating that 3,000, 6,000, or 9,000 yards, respectively, have been run on the beam.

The action of the measuring motion in stopping the warper is as follows: So long as the projection on the finger u_1 is running in the grooves of the barrel u, the different parts are in the position shown in Figs. 6 and 7. When, however, through the revolving of the barrel u, the projection on u_1 is caused to run over the end of the barrel and out of the grooves, the finger u_1 drops, causing the end u_2 to rise and the projection u_3 to catch on v_4, and prevent its rising. This will cause v, Fig. 6, to remain up, and as r_3 is brought down by the action of the cam it will catch the lever x and stop the machine in the same manner as with the stop-motion. The barrel u contains ten grooves, and by setting the projection on the finger u_1 in different grooves when starting a new beam, any number of wraps that may be desired, up to ten, can be run on the beam before the warper is stopped. For example, if the projection is set in the third groove from the end of the barrel, the barrel must make three revolutions before the machine is stopped. As each revolution of the barrel represents 3,000 yards run on the beam, then this will give a length of 9,000 yards in this particular case.

There is usually attached to a warper a clock that indicates the number of yards warped in any given length of time. This clock consists simply of a dial, on the face of which is

attached a finger that serves as an indicator. Suitable gearing is introduced to drive the finger from the measuring roll; consequently, as the measuring roll is turned by the yarn passing through the warper, it in turn moves the finger on the dial, and as suitable numbers are placed on the face of this dial, the total number of yards warped during any given time is readily determined by noting the position of the finger. If it is desired at any time to make a new start so as to determine the number of yards warped within another given time, the finger may be moved back to zero.

8. The **beam** on which the yarn is wound at the warper is shown at k, Fig. 1; another view is given in Fig. 8. The



FIG. 8

flanges k_1 are known as the *beam heads*, while k is the *barrel*. Beams for beam warpers are almost always made $54\frac{1}{2}$ inches between the heads, while the cylinders on which they run and by which they are driven are usually 54 inches wide. Beam heads may be either 18, 20, 21, 22, 23, 24, or 26 inches in diameter, while the barrel of the beam is usually 9 inches in diameter. A beam $54\frac{1}{2}$ inches between heads and with a 9-inch barrel will hold about 420 pounds of yarn when the heads are 26 inches in diameter. With 24-inch heads they will hold about 350 pounds; with 22-inch heads, about 285 pounds; and with 21-inch heads, about 255 pounds.

9. **Drive.**—Figs. 1 and 9 show the methods of driving the beam on which the yarn is wound. The belt that runs from the line shaft to the loose pulley p, may be shifted to the pulley p_1, known as the slow-motion pulley, or to the tight

pulley p. At present it is only necessary to consider pulley p_1, which, being setscrewed to shaft l_1, gives it motion; this shaft carries the gear l_2 of 21 teeth that drives the gear l_3 of 106 teeth on the cylinder shaft l_4. The beam k rests against the cylinder l and is driven by frictional contact; as a result, the surface speed of the beam remains the same all the time that the beam is being filled, and, since its diameter is con-

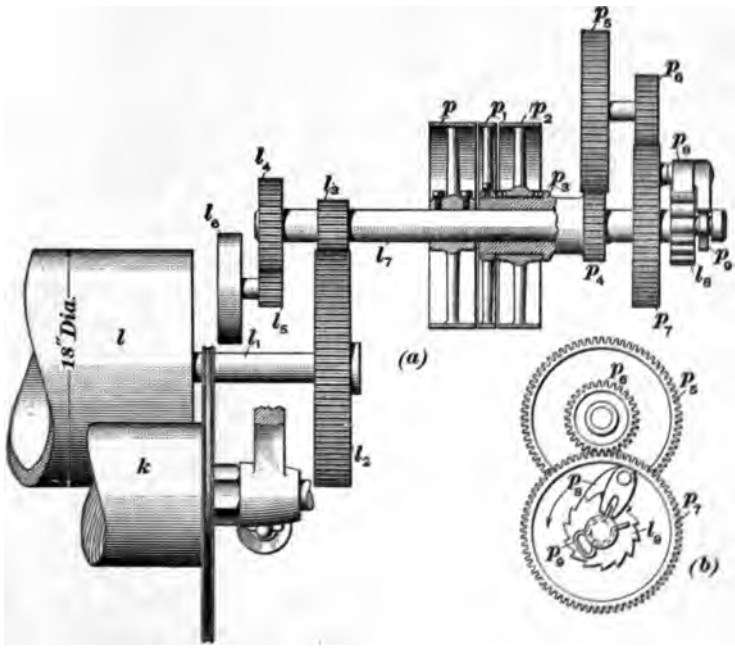


FIG. 9

stantly increasing, the number of revolutions per minute that it makes is constantly growing less. Since it is the winding of the yarn on the beam that draws the yarn from the spools, the yarn is unwound from the spools at the same speed throughout the filling of the beam.

10. Slow-Motion Arrangement.—Attachments are provided on all warpers by means of which they may be run at two speeds. When running at a normal speed, the belt is on the tight pulley p, Fig. 9 (a); but there are times

when the warper should be run slowly; for instance, in starting a warper, it is advisable to impart motion to the spools in the creel gradually, so that the yarn may not be subjected to a sudden strain. The advantage of a slow motion on a warper may be more readily understood when it is realized that the yarn taken by the drop roll must be made to assume a horizontal position before the warper can be run at its highest speed. In starting a warper, the operator shifts the belt to the slow-motion pulley, when the yarn immediately begins to wind on the beam, gradually pulling up the drop roll as the tension of the yarn counteracts the weight of the roll. As soon as the roll has resumed the position that it should occupy while the warper is running, and after the spools have acquired some momentum, the belt is moved to the tight pulley, when the machine will run at full speed.

The method adopted on this warper for altering the speed of the beam is shown in Fig. 9 (*a*). Pulley p_1 is known as the *slow-motion pulley*, since when the belt is running on this pulley, the speed of the cylinder is greatly reduced. As this pulley is fast to sleeve p_2, which is loose on the shaft, it drives gear p_4, which also is fast to the sleeve. Gear p_4 transmits its motion to gear p_7 by means of the compound gear p_5, p_6; a pawl p_8 is attached to the gear p_7 by means of a stud, while its tail is held by a spring p_9, shown more fully in Fig. 9 (*b*). As the gear p_7 revolves in the direction shown by the arrow, the tail is pressed against the end of the spring, and the pawl is caused to engage with the ratchet gear l_6, which being fast to the shaft l_7 gives motion to the cylinder of the warper. The number of teeth in these gears is p_4, 30; p_5, 72; p_6, 30; p_7, 72.

In the slow-motion drive, it must be remembered that the slow-motion pulley, the sleeve to which it is attached, and all the gears in the train (with the exception of the ratchet gear l_6) are loose on the shaft l_7 and, consequently, cannot have any effect on this shaft, except as they affect some mechanism connected to the shaft, which in this case is the gear l_6. When the belt is on the tight pulley the spring p_9, which is sprung around the shaft l_7, tends to revolve with the shaft and thus throws

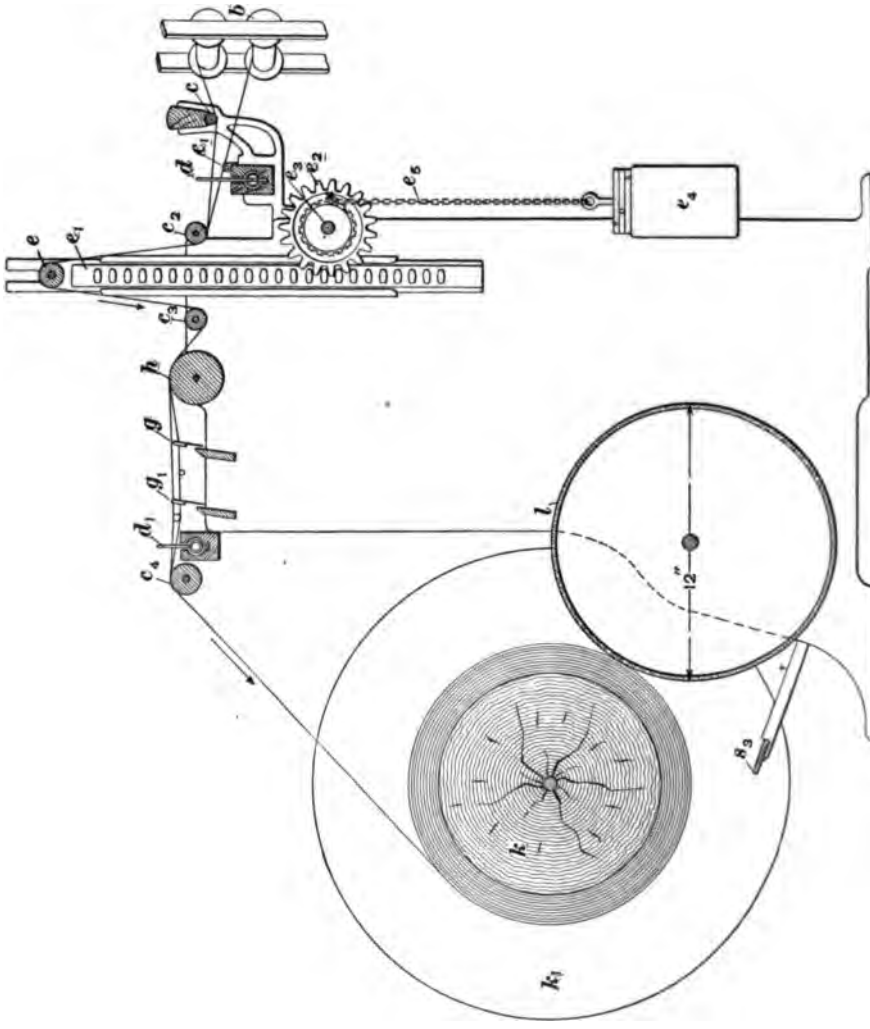
the pawl out of contact with the ratchet gear by engaging its tail. Under these conditions the slow-motion pulley p_1, sleeve p_2, gears p_4, p_5, p_6, and p_7, are stationary unless the friction between the shaft l_7 and sleeve p_3 is sufficient to give a slight motion to the sleeve. The heavy balance wheel l_8 is driven by the gears l_4, l_5, and serves to stop the machine gradually when an end breaks or the desired length has been run on the beam, thus lessening the liability of the ends overrunning on the spools in the creel.

DRAPER WARPER

11. Many parts of the **Draper warper** differ from those of the Entwistle warper. A section through certain of the parts of this warper is shown in Fig. 10; d, d_1 are the expansion combs; c, c_1, guide rods; c_2, c_3, c_4, guide rolls; h, the measuring roll; and e, the roll that takes up the slack yarn. The passage of the yarn from the creel to the beam is also shown, the direction being indicated by arrows.

12. **Rise Roll.**—As shown in Fig. 10, the slack yarn is taken care of by a **rise roll** instead of a drop roll. This rise roll is carried at each end in a sliding rack e_1, which contains teeth that engage with the gear e_2 on the shaft e_3. Motion is given to the shaft e_3 by means of the weight e_4 and chain e_5. The rise roll is kept down by the tension on the threads, so that should any slack yarn be let off, the weight e_4 drops; this causes the gear e_2 to revolve, and raises the rack e_1 and the roll e. When the yarn becomes tight again, the weight is prevented from dropping and the different parts assume the position shown in Fig. 10. When the machine is started, the tension on the yarn is sufficient to raise the weight, and the roll e consequently drops until the yarn forms a nearly straight line in passing from c_2 to c_3.

13. **Walmsley Stop-Motion.**—The stop-motion employed on the Draper warper is known as the **Walmsley stop-motion**; it is shown in Fig. 11. Certain parts that complete the operation of this stop-motion are also utilized in stopping the machine in connection with the measuring


b
c
d
c_1
e_3
e_2
e_5
e_4
e
e_1
c_2
c_3
h
g
g_1
d_1
c_4
l
12"
g_3
k
k_1

motion, so that one description will suffice for both. As shown in Fig. 11, a shaft s carries a treadle, or foot-board, s_3 at the front of the machine and also a lever extending toward the back of the machine, on which is a weight s_1. The weight of the foot-board is overbalanced by the weight s_1, so that there is a constant tendency for the foot-board to rise.

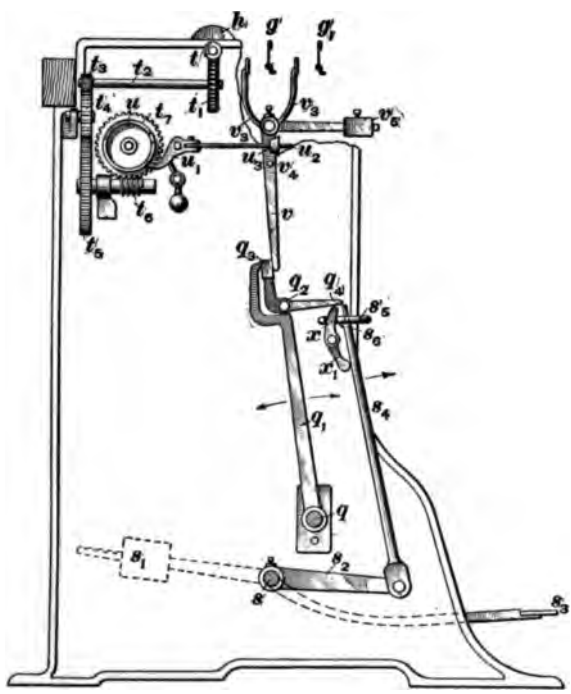


FIG. 11

Attached to the shaft s is a lever s_3 with a vertical rod s_4, carrying a projection s_6 at its upper end; s_5 is a bracket attached to the framework of the machine. When the foot-board s_3 is pressed downwards, s_6 drops below s_5 and catches under it; it is held in this position until the rod s_4 is pushed in the direction of the arrow, when the latch is released and rises, together with the lever s_3 and the foot-board, on account of the action of the weight s_1.

The rod q_1, by means of a cam on the cylinder shaft, is moved first in one direction and then in the other, as shown by the arrows in Fig. 11. This rod carries a latch q_3 working on a fulcrum q_2, which has a constant tendency to drop at the end q_4. In the position shown in Fig. 11, it is held against q_1 at its upper end by means of the arm v, which is kept pressed against q_3 by means of the weight v_1. As v is thus given an oscillating motion coinciding with the motion of q_1, the upper end of q_3 is kept pressed against q_1 by v, until other mechanism is brought into operation to prevent it. So long as these parts are kept pressed together, the machine continues to operate; but if by any means the lower end q_4 of q_3 is allowed to drop, it will come into contact with the upper end of the lever x and, at the next backward movement of the rod q_1, the upper end of x is pulled backwards by a projection on the arm q_4 and the lower end x_1 moved forwards into contact with s_4, pressing against s_4 with sufficient force to push the latch s_3 from its position below s_5; this allows the rod s_4 to rise and stop the machine.

14. The parts from s to the arm v form part of the broken-end stop-motion and the measuring motion; they are actuated either by a broken end or the measuring motion. The method by which they stop the warper when an end breaks will be first described; g and g_1 show the drop wires through which the threads pass, the pins being shown in the position they occupy when held upright by the threads. By the contact of the lower end of v with the lever q_1 through the arm q_2, an oscillating motion is given to the rod v and, consequently, to all parts mounted on it, including the arms v_2. When all the drop wires across the frame are vertical, each being supported by a thread, the arms v_2 swing on their fulcrum and the lower end of v keeps q_4 out of contact with x.

Should a thread break and a drop wire fall in front of either arm v_2, and thus hold it, q_1 is carried from v at the next backward movement; q_4 drops over x, pulling it backwards; x_1 is moved forwards; s_4 rises; and the machine stops. As these two drop wires are representative of all of the drop wires

across the warper, there being one to each end, it follows that no end can break without a drop wire falling in front of one of the oscillating bars. In this warper, the drop wires are in sets of three, each set mounted on a brass block.

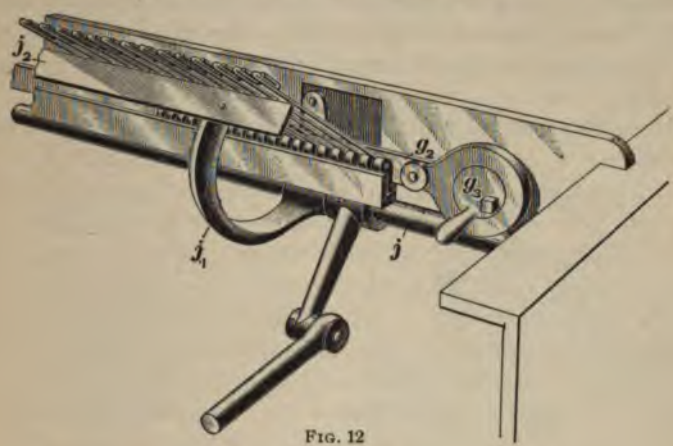


FIG. 12

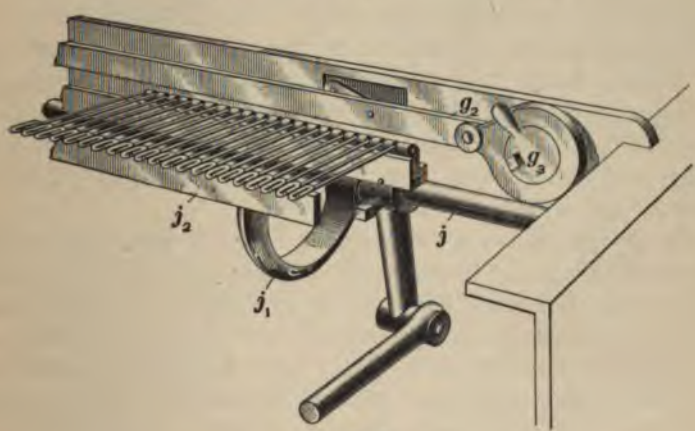


FIG. 13

One feature of the Walmsley stop-motion is shown in Figs. 12 and 13. When the eccentric g_3 is in the position shown in Fig. 12, a locking bar g_2 holds the blocks of the drop wires firmly in position, allowing the drop wires themselves,

however, to rise or to fall. When the eccentric is in the position shown in Fig. 13, the locking bar is raised and any one block carrying three drop wires can be removed. The bar j_2, supported by arms similar to j_1 that are mounted on the shaft j, rises when the machine is stopped by the broken-end stop-motion and brings all the drop wires into position to have the ends passed through them.

15. Measuring Motion.—The roll h, Fig. 11, acts as a measuring roll and is 9 inches in circumference. At one end of its shaft it carries a single-threaded worm t driving a worm-gear t_1 of 60 teeth on the shaft t_2. At the other end of t_2 is a gear t_3 of 20 teeth, which by means of a carrier gear t_4 drives t_5 of 100 teeth carried by the same shaft as a single-threaded worm t_6, which drives a 40-tooth worm-gear t_7 on the barrel u. The size of the measuring roll and of the gears intervening between it and the barrel u are such that 3,000 yards of yarn passes the measuring roll when u makes one complete revolution and, if it is set to knock off—that is, to stop the warper—at the end of 3,000 yards, it allows the blade u_1 to rise and the weight u_3 on the other end of the lever u_2 to drop when that number of yards has been measured. The weight u_3 falls on the pin v_4 on the rod v and, at the next oscillation of this rod, u_3 drops behind v_4 and holds the arm v away from q_3, which allows q_4 to come in contact with x and stop the machine.

The barrel u has a spiral groove of 10 complete turns, in any of which the blade u_1 can be inserted. If it were set in the rear one, $10 \times 3{,}000$ yards = 30,000 yards would be measured; if in the last groove but one, $9 \times 3{,}000 = 27{,}000$ yards would pass the roll. If it were placed one complete turn from the outer end of the barrel, u would revolve only once before stopping the warper and 3,000 yards would be measured. It will thus be seen that either 3,000, 6,000, 9,000, 12,000, 15,000, 18,000, or other multiples of 3,000 up to 30,000 yards can be accurately measured, while intermediate measurements can be made approximately by the position in which the barrel u is set before commencing operations.

16. Slow Motion.—The method adopted on the Draper warper to obtain the slow speed is illustrated in Fig. 14 (*a*) and (*b*). Working loosely on the short stationary shaft i_3 are the tight pulley p, slow-motion pulley p_1, and loose pulley p_2. When the belt is on the tight pulley p, motion is transmitted to the warper through the gear i, which is on the hub of this pulley and drives the gear i_1 on the shaft that imparts motion to the different parts of the warper. When it is desired to put the slow motion in operation, the

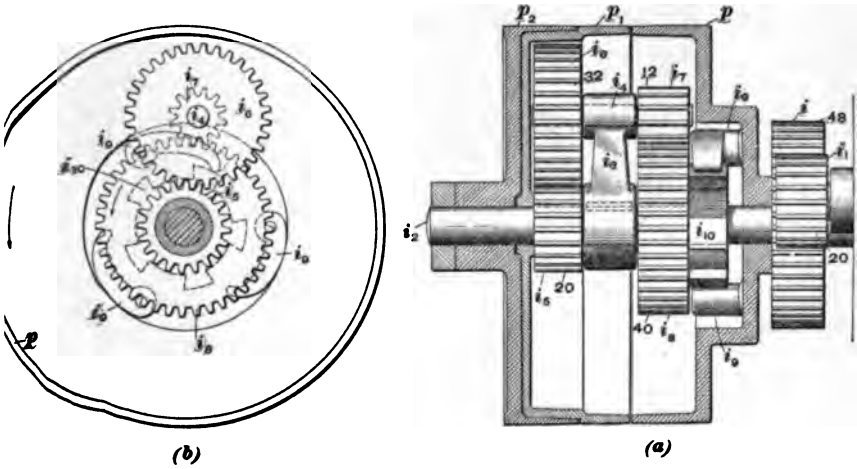


FIG. 14

driving belt is shipped to the pulley p_1. In order to understand the operation of the slow-motion mechanism it should be remembered that the shaft i_3 is stationary and simply serves as a support for the different parts mounted on it.

Fast to the hub of the pulley p_1 is a gear i_4 that drives a gear i_6 on a shaft supported by an arm i_3 that is keyed to the shaft i_3. On the shaft with the gear i_6 is a gear i_7 meshing with a gear i_8 that revolves loosely on the shaft i_3. On the hub of the gear i_8 is a ratchet gear i_{10}, which when the belt is on the slow-motion pulley is engaged by pawls i_9 that are supported on small studs fastened to the tight pulley p. Thus, when the belt is on the slow-motion pulley p_1, motion

is imparted to the tight pulley p, and consequently to the warper, through the gears i_5, i_6, i_7, i_8, i_{10}, and pawls i_9; but owing to the arrangement of these gears, the speed is very much less than when the tight pulley is driven directly by the belt. The tight pulley, when driven directly by the belt, revolves in the direction shown by the arrow in Fig. 14 (*b*), and the pawls i_9 are then inoperative, owing to their passing over the teeth of the ratchet gear i_{10}.

17. Cone Drive.—An attachment is provided on this warper by means of which the beam may be driven at a slower speed as the spools become nearly empty. The advantage of such an arrangement is clearly seen, for a spool filled with yarn is larger in diameter than an empty spool; consequently, if the same length of yarn is being unwound from each in the same time, the spool that is nearly empty must make more revolutions per minute than the other, which is undesirable. In addition, as the diameter of the spool decreases the amount of pull necessary to turn it is increased, which naturally brings more strain on the yarn. If, therefore, the same length of yarn is to be unwound from the spools at all times this length cannot exceed what the yarn will stand when being unwound from the nearly empty spool; consequently, when the spools are full, the warper is not run at its full capacity. It is to overcome this defect that the **cone drive** has been introduced; it is illustrated in Figs. 15 and 16.

The top cone m, which is on the same shaft as the gear i_1, Fig. 14, drives the bottom cone m_1 by means of the belt o_3, the position of which is controlled by the belt guide o_1. Connected to the top of the belt guide o_1 is a chain o that passes around the pulley o_2 and is attached to the pulley o_4. Another chain o_5 that is also attached to the pulley o_4 is connected to the lower end of the belt guide o_1. The action of the two chains o, o_5 is as follows: If the pulley o_4 is revolved in the direction shown by the arrow, the chain o is wound up and the chain o_5 let out, which will draw the belt guide o_1 to the left and move the belt o_3 toward the small end of the top cone m, resulting in the bottom cone m_1 being driven at a

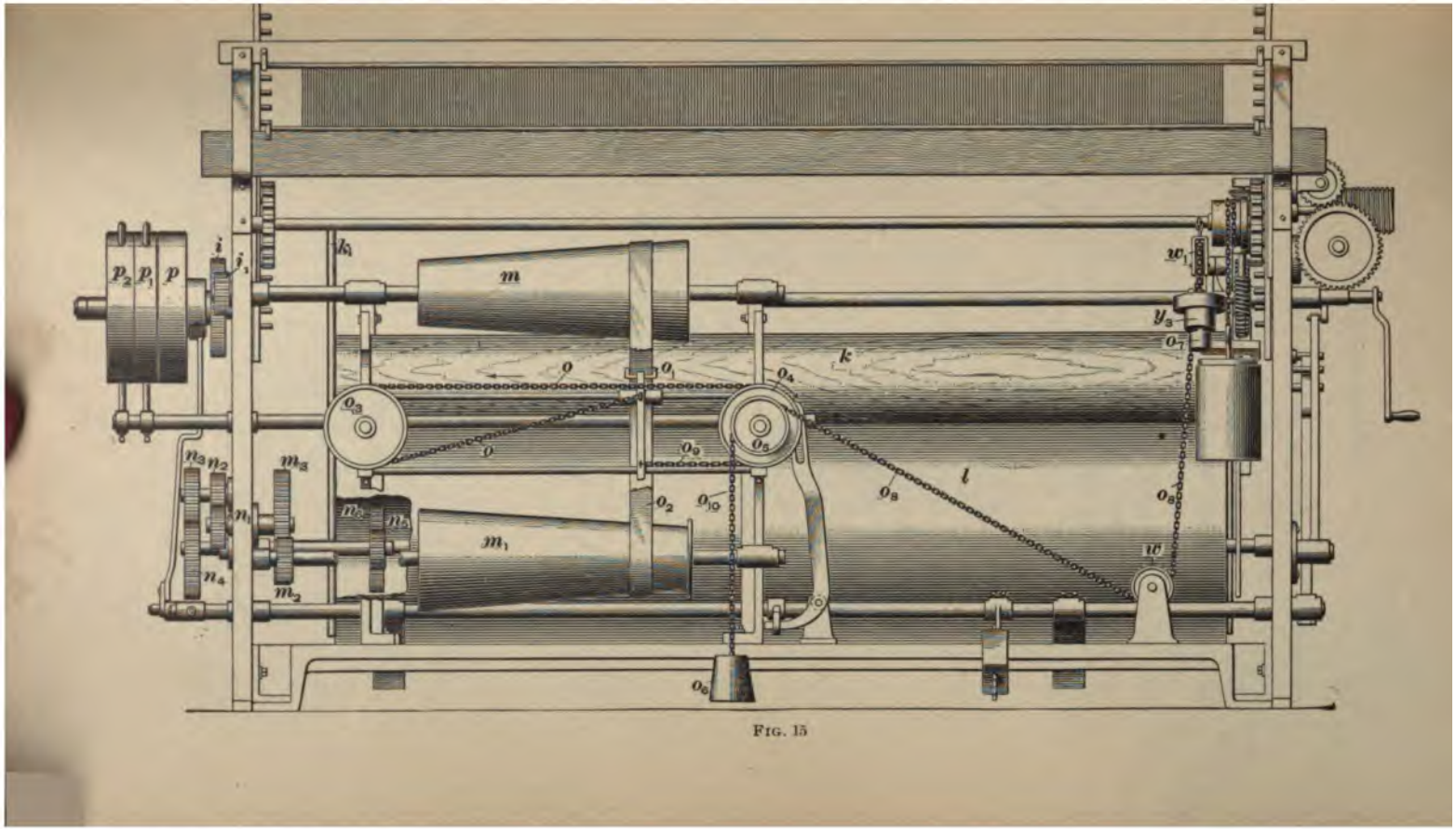

p_2 p_1 p
i
j
k_1
m
w_1
y_3
o_7
o
o_1
o_4
k
o_3
o_5
o_9
o_{10}
o_2
o_8
o_6
l
n_3 n_2
n_1
n_4
m_3
m_4
m_1
m_2
w

FIG. 15

slower speed. If the pulley o_4 is revolved in the opposite direction, the chain o_9 will be taken up and the chain o let out, moving the belt guide, together with the belt, to the right and increasing the speed of the bottom cone. The pulley o_4 is controlled by two chains o_{10}, o_8, each of which is attached to the pulley o_9 on the stud with the pulley o_4. The chain o_{10} supports the weight o_8, while the chain o_9 passes partly around the pulleys w, w_1 and supports the weight o_7. The weight o_8 is made heavier than the weight o_7; consequently, if only

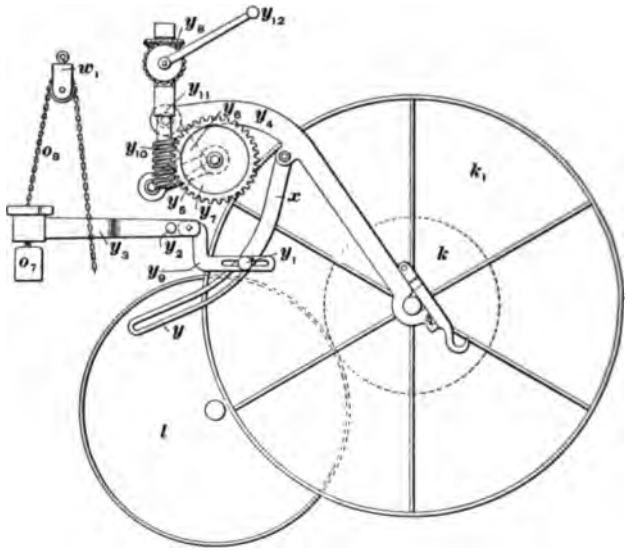


FIG. 16

these two weights were considered, the chain o_{10} would revolve the pulley o_8, together with pulley o_4, in the direction opposite to that shown by the arrow. When, however, the machine is running, an arm y_3, which is weighted at this end, rests on the weight o_7, and the combined weight of these two parts is sufficient to overbalance the weight o_8, causing the pulleys o_4, o_3 to revolve in the direction shown by the arrow and the belt to be moved gradually toward the small end of the driving cone m. The manner in which the arm y_3 is controlled is explained in connection with Fig. 16.

The beam k is supported by arms y_4, which are fulcrumed at points y_{11}. When an empty beam is placed on the cylinder l, the diameter is of course the smallest, being only that of the barrel k. As yarn is wound on the beam, the diameter becomes larger, which causes the arm y_4 to rise. To the arm y_3, which is fulcrumed at y_2, is connected a short arm y_6 with a slot into which a pin y_1 is bolted; this pin engages with a slot y in the arm x. The slot in the arm y_6 allows the pin y_1 to be accurately adjusted with the slot y, while the arm y_3, being weighted at its outer end, keeps the pin pressed against the upper end of slot y. As the arm x is attached to the arm y_4, which carries the bearings of the beam, it follows that as the arm y_4 rises, the arm x will also rise and with it the slot y. This action of the different parts allows the outer end of the arm y_3 to drop, thus causing the weight o_7 to descend also and move the belt toward the smaller end of the driving cone by means of the chains o, o_8. When an empty beam is placed in the warper, the arm x will assume its lowest position, which will push down the pin y_1 and bring the weighted end of lever y_3 to its highest position. As the warper is started, the chain o_{10}, Fig. 15, will, on account of the weight o_8 overbalancing the weight o_7, revolve the pulleys o_4, o_5 in the direction to move the belt toward the large end of the top cone. This action will continue until the weight o_7 has been raised sufficiently to come in contact with the arm y_3, when the belt should be at the largest diameter of the driving cone m.

In this manner the size of the beam regulates the position of the belt. In order that this motion may act to the best possible advantage, it is necessary that full spools should be placed in the creel when an empty beam is placed in the warper, since in this manner the beam becomes larger as the spools are gradually reduced in size; consequently, the number of revolutions per minute that the spools make is approximately the same throughout the filling of the beam. Since one set of spools will not fill two beams, the spools are generally broken out and full ones inserted after a beam has been filled. The partly full spools are refilled at the spooler.

The manner in which the bottom cone drives the cylinder is as follows: The gear m_2, Fig. 15, is on the bottom cone shaft and drives m_3. On the shaft with m_3 is the gear n_1 that drives n_2, this gear being on a sleeve with n_3; n_3 drives n_4, which is on a shaft extending into, but not connected to, the cylinder and carries at its other end the gear n_6 that drives n_6 on the cylinder shaft. The number of teeth on each of these gears is as follows: m_2, 24; m_3, 64; n_1, 23; n_2, 23; n_3, 28; n_4, 48; n_5, 20; n_6, 46.

18. Beam Doffer.—Another device provided on the Draper warper is the **beam doffer**, by means of which it is

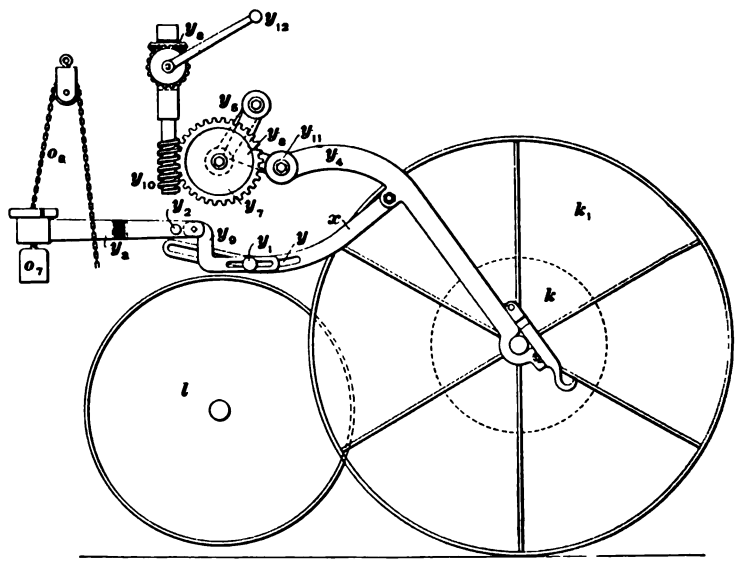


FIG. 17

possible for one man to place the filled beam on the floor with very little exertion. It is shown in Fig. 16 as it appears when the warper is in operation, while Fig. 17 shows the different parts in the positions that they assume when the beam has been lowered to the floor. This arrangement consists of a crank-arm y_4 supporting the two arms y_6, y_4 in such a manner that the distance between the centers of the beam k and the

gear y_7 is short when the beam is running, but may be increased by turning the crank y_{12}. The rotary motion of this crank transmitted by the gears y_8, worm y_{10}, and worm-gear y_7 moves the crank-arm y_6 and arms y_5, y_4 into the position shown in Fig. 17, thus lowering the beam, as shown, to the floor or to a beam truck placed to receive it.

CALCULATIONS AND MANAGEMENT OF WARPERS

CALCULATIONS

19. The **calculations** that are required in connection with warpers relate almost entirely to speed and, consequently, will not require any detailed description. One illustration, however, will be given as an aid in solving any problems that may be met with in connection with warpers.

EXAMPLE.—Find the greatest speed of the cylinder of the warper illustrated in Figs. 14 and 15 if the tight pulley p is driven 200 revolutions per minute.

NOTE.—The cones are 4¼ inches in diameter at their small ends and 6¼ inches in diameter at their large ends.

SOLUTION.—

$$\frac{200 \times 48 \times 6\frac{1}{4} \times 24 \times 23 \times 28 \times 20}{20 \times 4\frac{1}{4} \times 64 \times 23 \times 48 \times 46} = 67.13 \text{ rev. per min. Ans.}$$

MANAGEMENT

20. The **management** of a warping equipment requires careful attention, more particularly with regard to obtaining hard and level beams, free from ridges or soft sides near the beam head. The existence of ridges indicates a wrong division of the ends in the comb, while soft sides show that the comb has not been adjusted to suit the width of the beam. All knots that are made during the filling of a beam should be made as small as possible in order to facilitate the weaving process. In beam warping, it is customary to run the ends so that in being wound on the beam they

will run over instead of under the beam, it being claimed that when wound in this manner it is easier to find and tie any broken ends.

Warpers are usually tended by women, who can give attention to from two to eight machines, the number depending on the class of yarn that is being run, and the amount of assistance that is rendered them in refilling the creels and other work, outside of that of actually operating the machines. The attendants are usually paid by the piece.

21. The actual production of warpers should be estimated at from 65 to 75 per cent. of the production figured on the basis that the machines are run constantly, as warpers are stopped from 1½ to 2 hours for creeling after each set of spools has been run off. The production is usually figured at 70 yards per minute for 20s; 60 yards per minute for 40s; 50 yards per minute for 60s; 45 yards per minute for 80s; and 40 yards per minute for 100s. This estimate will vary in different mills, according to the speed of the machines, the quality of the yarn, and the number of warpers being run by each tender.

Table I gives the production per week of 60 hours for yarns from 8s to 50s, the number of ends on the beam varying from 260 to 440 and the speed of the warper being about 54 yards per minute. The production with other speeds can easily be figured by proportion. This table provides for an allowance of 33⅓ per cent. lost time for stoppages.

22. As a number of the section beams on which the yarn is wound at the warper are later wound on one loom beam, it is necessary before making any beams on the warper to first find how many should be made and just how many ends there should be on each beam. For example, suppose that it is desired to ultimately place 1,790 ends on a loom beam. Before the section beams are made for this loom beam, the number of ends to be placed on each section beam must be ascertained. Thus, in this case it would be possible to make four section beams, three beams containing 450 ends

each, and one beam containing 440 ends, the total number of ends being 1,790, which is the number desired for the loom beam. Any other division could be made so long as the number of ends placed on any one section beam did not exceed the number of spools that it is possible to run in the creel of the warper.

TABLE I

Number of Ends	260	300	320	340	360	380	410	440
Number of Yarn	Pounds Warped in 60 Hours							
8	5,015	5,785	6,171	6,557	6,943	7,329	7,907	8,485
10	4,011	4,629	4,937	5,246	5,555	5,863	6,325	6,789
12	3,343	3,857	4,181	4,372	4,629	4,885	5,271	5,657
14	2,865	3,305	3,527	3,747	3,967	4,188	4,519	4,849
16	2,507	2,893	3,085	3,279	3,471	3,664	3,953	4,243
18	2,229	2,571	2,743	2,915	3,085	3,257	3,515	3,771
20	2,005	2,315	2,468	2,623	2,777	2,931	3,163	3,395
22	1,823	2,104	2,244	2,385	2,525	2,665	2,875	3,085
24	1,671	1,925	2,057	2,185	2,315	2,443	2,636	2,829
26	1,543	1,780	1,899	2,017	2,136	2,255	2,433	2,611
28	1,433	1,653	1,763	1,873	1,983	2,094	2,259	2,425
29	1,383	1,596	1,703	1,809	1,915	2,021	2,181	2,341
30	1,337	1,543	1,645	1,749	1,851	1,955	2,109	2,263
32	1,253	1,447	1,543	1,639	1,736	1,832	1,977	2,121
34	1,180	1,361	1,452	1,543	1,633	1,725	1,861	1,997
36	1,115	1,285	1,371	1,457	1,543	1,629	1,757	1,885
38	1,056	1,219	1,299	1,380	1,461	1,543	1,665	1,787
40	1,003	1,157	1,235	1,311	1,389	1,465	1,581	1,697
44	912	1,052	1,123	1,192	1,262	1,332	1,437	1,543
50	806	925	987	1,049	1,111	1,171	1,265	1,357

23. A standard warper with a 54-inch cylinder and with a creel for 400 spools occupies over all a space of about 17 feet by 7 feet 6 inches, while a larger warper with a creel for 450 spools occupies a space of 18 feet by 8 feet. The warper itself without the creel occupies 3 feet 6 inches by 7 feet 6 inches. The driving pulleys of a warper are usually 10 inches in diameter and are driven by a 2-inch belt. From $\frac{1}{4}$ to $\frac{1}{3}$ horsepower is required to drive one warper.

In equipping a mill, it is customary to estimate on about eighteen beams to each warper, in order to afford a sufficient supply for storing yarn and making up the assortments for the slasher; these beams are sometimes called *section beams*, sometimes *slasher beams*.

The weight of the warper itself, that is the machine, is about 1,000 pounds, and of a creel for 450 ends about 450 pounds, so that the shipping weight of a warper with creel and beams is from 2,500 to 3,000 pounds.

A warper is said to be right-hand if the driving pulleys are on the right-hand side when the observer is standing in front of the warper, that is, facing the beam, and left-hand if the driving pulleys are on the left hand when the observer is in the same position.

SLASHERS

GENERAL CONSTRUCTION

INTRODUCTION

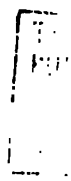
1. The warp beams as they come from the warper, in addition to not being the correct width for the loom, do not contain the desired number of ends for weaving, since they are limited in this respect by the creel capacity of the warper. Consequently, it is necessary to take the ends from a number of beams made at the warper and run them on one loom beam. In making up a number of section beams, the number of ends that the warp is to contain is always considered, and the total number of ends on the section beams always equals the desired number of ends for the body of the warp. When the selvage ends are composed of single yarn and of the same counts as the warp yarn, they are also placed on the section beams, but in case the selvage ends are composed of ply yarn they are usually run from spools placed in a special creel behind the slasher. Again, the yarn, when on the section beam, is not in a suitable condition to withstand the strain placed on it during weaving. Warp yarn when in the loom is drawn through harnesses that are constantly moving up and down and is also drawn through narrow slits of a reed that is constantly moving back and forth. Both the harnesses and reed chafe the yarn to such an extent that single cotton yarn cannot stand the treatment unless it is especially prepared. Consequently, it is customary in the cotton trade to apply to the warp threads a solution known

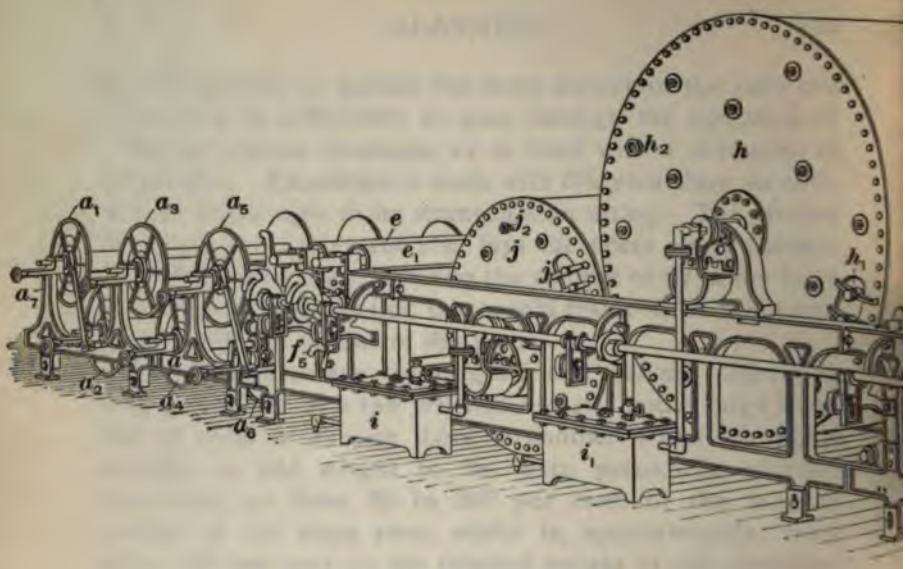
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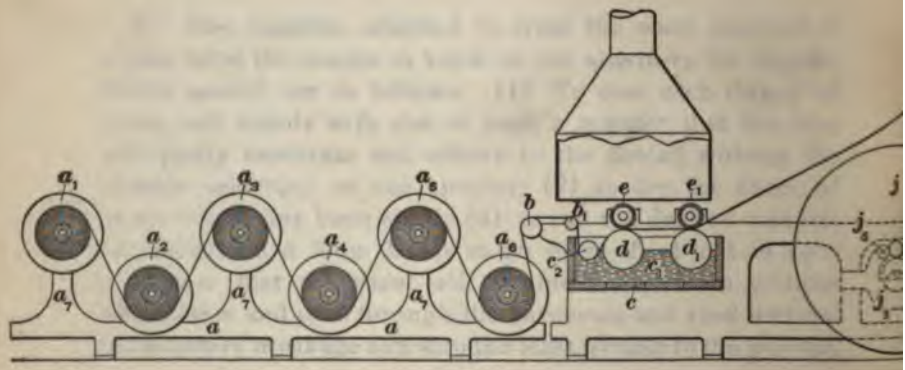
as *size*, in order to harden the outer surface of the yarn and strengthen it sufficiently to pass through the operation of weaving without breakage, or at least with a minimum of breakages. Experiments made with 60s yarn show an addition of 10 per cent. to its strength after sizing. The process of sizing to some extent also lays the fibers along the surface of the warp yarn, reducing the amount of fly at the loom and the additional friction that would result if the fibers projected from the surface of the yarn.

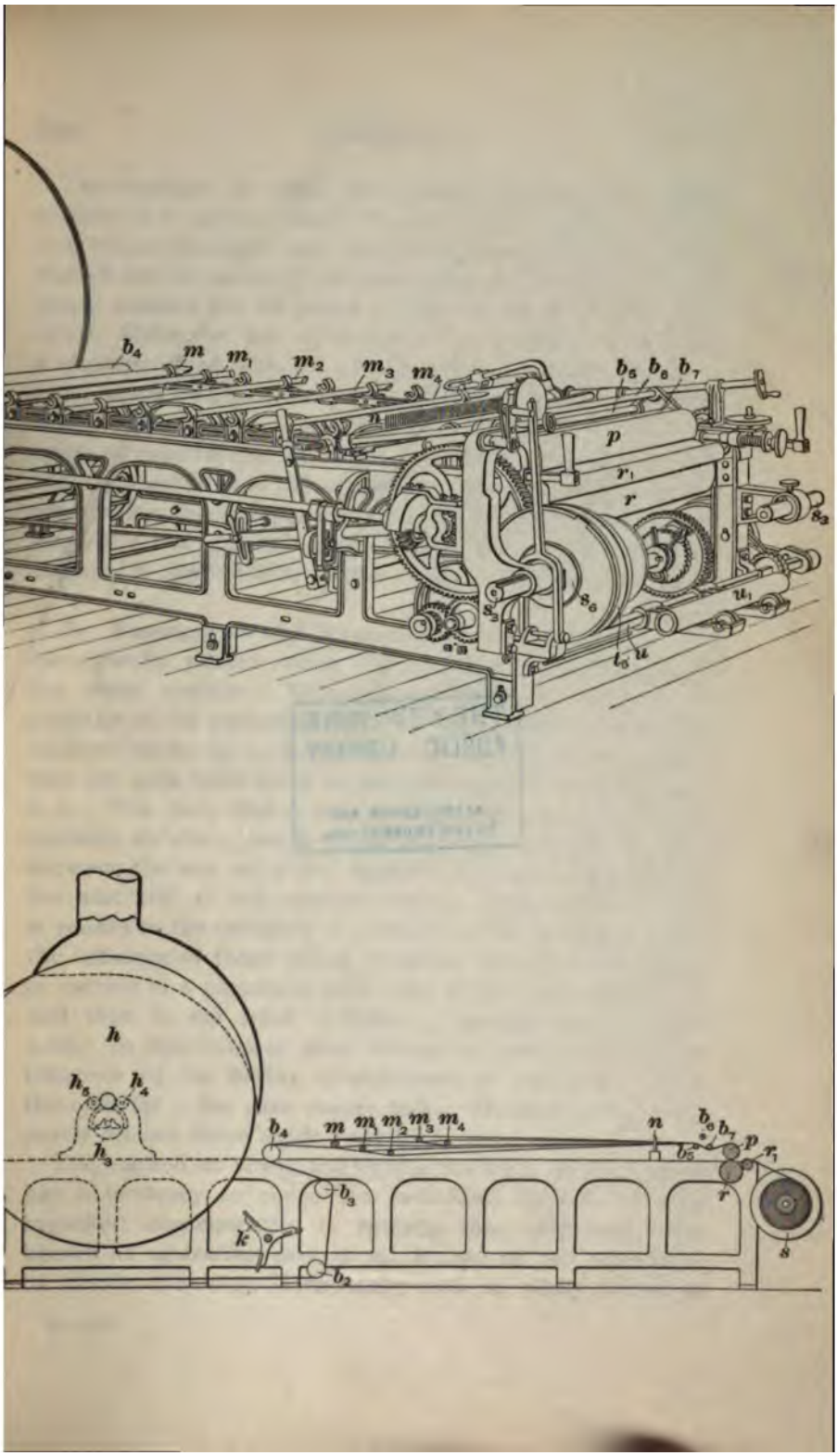
The foregoing are the original and general objects of sizing yarn, but in a few mills in America and a large number of mills in Europe there is another object of sizing; namely, to add weight to the warp yarns, the addition amounting to from 20 to 250 per cent. of the original weight of the warp yarn, which is, approximately, from 10 to 125 per cent. of the original weight of the combined warp and filling yarns. This is done in those mills making fabrics for India, China, and other markets where there is a demand for a cheap fabric not required to withstand much wear and tear or frequent washing and which it is necessary to supply at a price that would not permit the use of pure cotton yarns having the bare addition of sufficient size to enable the warp to be woven. This heavy sizing is outside the scope of this Section, which will deal only with what is known as *pure sizing;* namely, just sufficient to enable the warps to weave satisfactorily.

2. The machine adopted to treat the warp yarn as it comes from the warper is know as the **slasher;** its objects, briefly stated, are as follows: (1) To coat each thread of warp yarn evenly with size in such a manner that the size will partly penetrate and adhere to the thread without the threads adhering to one another; (2) to dry the sheet of warp after it has been sized; (3) to run the desired number of threads on a loom beam in an even sheet and in such a manner that the sheet will unwind at the loom without obstruction and pass through the harnesses and reed without unnecessary breakage and with the least trouble to the weaver.




a_1
a_3
a_5
a_7
a_2
a_4
a_6
a
e
e_1
f_5
i
i_1
j
j_2
h
h_2
h_1


a_1
a_3
a_5
a_2
a_4
a_6
a_7
a
b
b_1
c
c_2
d
d_1
e
e_1
j
j_2
j_3


b_4 m m_1 m_2 m_3 m_4 b_5 b_6 b_7
p r_1 r s_3 u_1 s_2 s_6 t_5 u
h h_6 h_4 h_3
b_4 m m_1 m_2 m_3 m_4 n b_6 b_7 p r_1 b_5 r s
b_3 k b_2



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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

The manner in which the slasher accomplishes these objects is to pass a sheet of warp from a number of section beams through a box containing hot size and allow it to absorb size in excess of what is required, the excess of size being pressed out by presser rolls; the moist warp is then dried, either by hot cylinders or by passing it through a chamber filled with hot air, and later cooled by means of fans, after which it is separated into individual threads and wound on the loom beam. Slashers are of various types of construction, although they may be divided into two classes according to the method by which the warp is dried after it has been sized; namely, *cylinder slashers* and *hot-air slashers*. The general type in use, both in America and Europe, is the cylinder slasher, usually with two cylinders.

3. Passage of the Yarn.—Fig. 1 shows a view of a two-cylinder slasher, while Fig. 2 shows a section through the same machine. Referring to these two figures, the passage of the yarn is as follows: The required number of section beams a_1, a_2, a_3, a_4, a_5, a_6 are placed in the creel a and the ends from these beams passed over the guide rolls b, b_1. The yarn then passes through the size box c, which contains the size c_1, being guided under the immersion roll c_2, between the size roll d and squeeze roll e, and then between the size roll d_1 and squeeze roll e_1. From the size box it passes to the cylinders h, j, but in order to keep it under the influence of these drying cylinders as long as possible it is carried in a circuitous path, first to the large cylinder h, and then to the small cylinder j, passing partly around both. In this manner about 50 feet of warp is under the influence of the drying arrangement at one time. From the cylinder j, the yarn passes under the cooling fan k and partly around three guide rolls b_2, b_3, b_4.

The method of sizing and drying the warp on the slasher has a tendency to cause the individual threads to stick together; consequently, to remedy this, *split rods*, also known as *separating bars*, m, m_1, m_2, m_3, m_4 are introduced to divide the warp horizontally into as many sheets as

there are section beams in the creel. The warp next passes through the expansion comb n, over and under tension rods b_5, b_7, partly around the measuring roll p, partly around the drag roll r and guide roll r_1, and then to the loom beam s, on which it is wound in an even sheet. The tension rods b_5, b_7 aid in regulating the tension of the yarn between the cylinders and the drag roll, while the rod b_6 serves simply as a rest for the operator in placing the ends in the dents of the expansion comb n.

4. Cylinder slashers may be divided into four distinct sections as follows: (*a*) The *creel* in the rear for holding the section beams; (*b*) the *sizing apparatus* for sizing the warp, which consists of the size box and its various appliances; (*c*) the *drying apparatus* for drying the warp after it is sized, which consists of the cylinders h, j, Figs. 1 and 2, and their various appliances; (*d*) the *headstock*, which consists virtually of the different parts situated in front of the cylinders. These parts will be described in this order.

DETAILS OF CONSTRUCTION

CREEL

5. A slasher **creel** consists principally of a stand a, Figs. 1 and 2, carrying the uprights a_7 that support bearings in which the shafts of the section beams rest; these uprights, of which there are usually three, support the beams that form the upper tier. In addition to the bearings for the beams in this upper tier, there are also an equal number of bearings to support a lower tier of beams. These bearings are adjustable and may be moved out or in to suit the width of the beams. It should be understood that it is not always necessary to have the number of section beams equal to the capacity of the creel, since if five, or even four, beams can be made to hold the required number of ends most advantageously, that number should be used. In any case, however, it is first necessary to determine the number of beams to be used and the number of ends on each beam, so that the total number

of ends from all the beams will exactly equal the number of ends that it is desired to have on the loom beam. For example, suppose that it is desired to place 2,438 ends on the loom beam; then it will be possible to have three section beams each containing 490 ends and two section beams each containing 484 ends, the total number of ends being 2,438. These five beams should be placed in the creel in two tiers, three in the lower tier and two in the upper, since it is the custom when filling the creel to commence at the end nearer the size box. If there is no difference in the length of space between the heads of the different beams, the three beams containing the larger number of ends should be placed nearest the size box; while on the other hand, if the beams vary in regard to the space between the heads, the widest should be placed nearest the size box and the others arranged accordingly, irrespective of the number of ends on the different beams. This arrangement allows the sheet of warp leaving the rear beam to come between the heads of the next beam, and so on up to the beam placed next to the size box. If this is not done, the sheet of warp from a wide beam will rub against, and very likely run over, the heads of a narrower section beam.

The manner in which the yarn is gathered from the section beams is as follows, referring to Fig. 2 and considering that there are six beams in the creel: The tender first takes the yarn from the beam a_1 and passes it under the beam a_2, thus causing the sheet from this latter beam to come above that from the beam a_1. The ends from the two rear beams are then passed over the beam a_3, when the ends from this beam are joined with those from the beams a_1, a_2, the ends from the beam a_3, however, lying under those from the two other beams. In a similar manner the yarn is passed under the beam a_4, over the beam a_5, and under the beam a_6, the yarn from each beam being combined with the yarn from the preceding beams as the sheet of warp passes that beam. Thus, if we should consider the sheet of ends from each beam as solid with no space between the different ends, there would be six distinct layers passing over the roll b, the three from the lower beams being above the three from the upper beams

and the whole being arranged as follows: The top layer consists of ends from a_6; the next layer consists of ends from a_4; the next of the ends from a_2, which completes the beams in the lower tier. Then come the ends from a_1; next, the ends from a_3; and then the ends from the beam a_5. Of course, what actually takes place is that the ends from all the section beams spread out into one even sheet, which is necessary in order to have the yarn dry satisfactorily when passing around the cylinders.

6. Leasing the Warp.—At the commencement of a set and also at frequent intervals during its running, lease bands have to be inserted at the creel between the sheets of yarn at each point where the sheet from one beam effects a junction with the sheet from another. In case six beams are placed in the creel, five bands are inserted, three of them being laid across the warp yarn from above and two from beneath. These bands consist of pieces of double cord or, preferably, several ends of warp yarn. In order to have the bands in position for insertion between the sheets of warp from beneath, the two that are to be raised from below the warp yarn are placed on the floor crosswise of the creel and directly under the points where they are to be inserted. In placing the bands in position, the slasher tender employs a rod equal in length to the width of the creel. By passing one end of the band around the rod the band may be laid in any desired position and the rod removed. While the machine is running slowly, the first band is inserted; namely, the one that is laid above the warp between the beams a_1 and a_2, Fig. 2. After this band has gone forwards, a band is raised from beneath the warp between a_2 and a_3 and allowed to go forwards; then one is placed above the warp between a_3 and a_4; then one under the warp between a_4 and a_5; and, finally, one above the warp between a_5 and a_6.

Great care should be taken to keep the ends of the lease bands overhanging the beam flanges, but just before the warp enters the size box they should be folded over the edges of the warp, to prevent their being drawn out or

getting entangled in going through the machine. As the bands reach the front of the machine the split rods are inserted in their place, as will be explained.

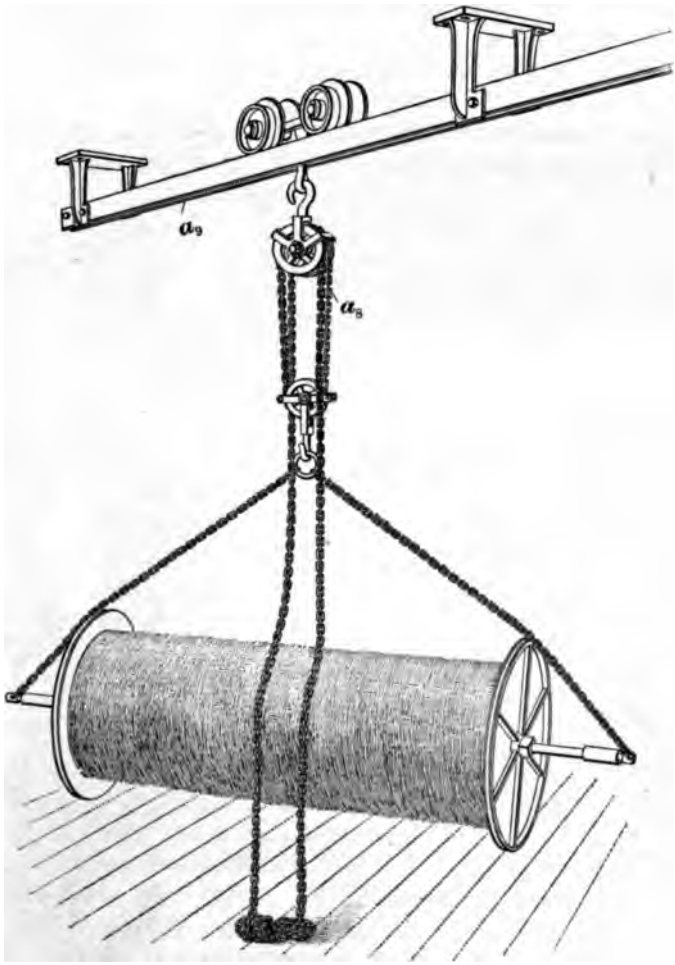


FIG. 3

Breakages of ends and other accidents during the operation of the machine sometimes disarrange the position of the threads, and it is therefore advisable once or twice during

the running of a set to repeat this operation of inserting lease bands. Some mills where very particular work is done require a lease to be taken as each loom beam is filled. Where tender yarn is used it is advisable to do so for every beam.

The method of inserting lease bands just described is not the only method. Some slasher tenders use it only when taking a lease during the running of one set, and when starting a new set reverse the order of inserting the bands. The word *set*, as used in connection with the slasher, means a set of section beams; thus, for instance, six section beams in the creel of a slasher would be considered a set. *Running a set* means slashing all the yarn contained on this set of beams.

7. Overhead Track.—It is advisable, and in well-equipped slasher rooms is customary, to provide facilities for raising the section beams and inserting them in the creel at the back of the slasher. These arrangements usually consist of a hoist a_3, Fig. 3, running on a track a_4. One of these tracks is situated over each creel and it becomes an easy matter to carry the section beams to their places along the track and lower them into position. In mills using extremely large loom beams, it is also of advantage to provide a track and hoist at the front of the machine by which the loom beams can be removed from the slasher.

SIZE BOX

8. The **size box** consists primarily of a wooden box about 3 feet wide and equal in length to the width of the slasher. This box is shown at c, Fig. 2, but a more detailed view is given in Fig. 4, which shows the various parts as looked at from the opposite side to that shown in Fig. 1. When the slasher is in operation, the size box is partly filled with size c_1 and the immersion roll c_2 placed in such a position that the yarn in passing partly around it passes through the size, becomes coated with it, and to a certain extent absorbs the mixture in excess of the requirements. The excess of size is pressed out as the yarn passes

between the two sets of rolls d, e and d_1, e_1 and flows back into the box.

9. Steam Connections.—As the size should be in a boiling state when applied to the yarn, steam is usually injected into the size box. The main line of pipe for conveying the steam to the slasher is shown at f, from which a branch pipe f_1 runs to the size box and enters it near the bottom and at the center, as shown at f_2. This pipe extends across the size box, while at each end two branch pipes, one running to the right and the other to the left, extend to the two

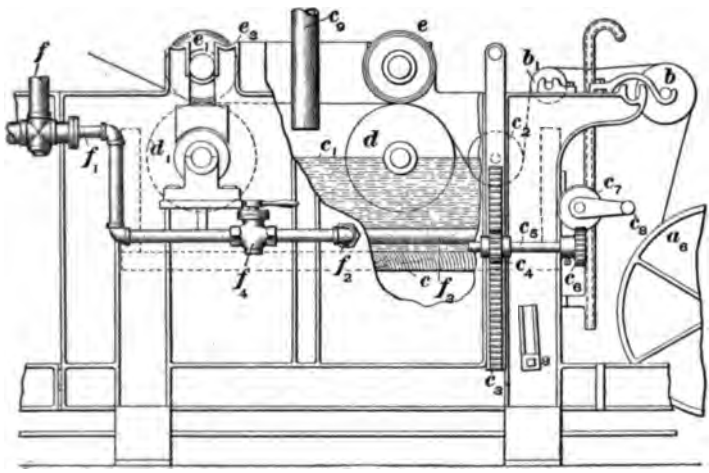


FIG. 4

sides of the box, where they are connected to another pipe running lengthwise of the box; thus, there is one pipe running lengthwise of the box near its center, while other pipes extend around the inside of the box near its four sides. One of the pipes that branches from the central one is shown at f_3, Fig. 4. The pipes that are contained in the size box are perforated with small holes, through which steam is blown into the size, which is thus kept in a boiling state. The valve f_4 provides a ready means for shutting off the steam from the size box when it is desired to do so, while on the other side of the box, as shown at f_5, Fig. 1,

is provided a faucet for drawing off the size when it is desired to empty the box.

In some machines, the size box has a steam jacket at the bottom of the box, no steam being admitted to the size. With this method the size is boiled without allowing the steam to condense in it. It is claimed that this method keeps the size in the box of a more uniform consistency, since the injection of steam tends to thin the size, owing to the fact that the steam condenses and forms water.

10. The size rolls d, d_1 are positively driven by means of bevel gears situated on the side of the slasher, shown in Fig. 1, while the squeeze rolls e, e_1, Fig. 4, are driven by frictional contact with the lower rolls. As the squeeze rolls are especially heavy and covered with cloth, these two sets of rolls grip the sheet of yarn sufficiently to pull it from the section beams and through the size box. The rolls d, d_1 revolve in fixed bearings, but the bearings of the rolls e, e_1 are carried in vertical slots, which allows them to be raised if necessary and placed on stands e_2, e_3, thus bringing them out of contact with the size rolls.

The ends of the immersion roll c_4 rest on a rack c_5, the teeth of which engage with a gear c_6 on a short shaft c_8 that carries at its other end a gear c_9. A worm c_7 that engages with the gear c_9 is on a stud with a handle c_{10}, by turning which the immersion roll may be readily raised or lowered as desired. It is frequently necessary to change the position of this immersion roll, since the size is not always the same depth in the size box and yet the size should continually cover the same amount of surface of the immersion roll, at least while sizing the same set of beams, in order to insure the yarn being uniformly sized.

As the hot steam that rises from the boiling size would tend to rust any ordinary rolls with which it should come in contact and thus damage the yarn passing over these rolls, the rolls b_1, c_2, d, d_1 are made of copper, while the rolls e, e_1 are covered with cloth.

11. **Covering Squeeze Rolls.**—The squeeze rolls e, e_1, Fig. 4, are common iron rolls about 6 inches in diameter;

they are first covered with three or four layers of ordinary cotton sheeting, which is either glued on or thickly coated with white paint, the paint preventing the size from striking through and reaching the roll. One of the chief objects of the squeeze rolls is to cause the size to penetrate the yarn, and in order to accomplish this there is placed outside of the cotton cloth covering a woolen blanket especially made for this purpose and technically known as *slasher cloth*. For the rear roll from $3\frac{1}{2}$ to 4 yards of 16-ounce cloth and for the front roll from 4 to 5 yards of 12-ounce cloth will be found to give good satisfaction. In placing the cloth on the rolls, care should be taken to have the laps follow on the outside, so that they will not be roughed up. It is hardly necessary to fasten the cloth in any manner, as the size will soon stick the laps together, but should any part of the outer edge of the cloth become folded, thus causing a bunch on the roll, it may be laid smooth by passing the end from a bobbin of yarn around the roll a number of times. Slasher cloth, through being in constant contact with the size, soon becomes stiff and unpliable; to remedy this it should frequently be taken off and soaked in water. After the cloth has become so worn as to be unserviceable, it should be replaced by a new one.

12. Size Kettle.—The size is usually supplied to the size box by a pipe c_3, Fig. 4, that runs from a **size kettle**, which contains a large quantity. It is usual to erect these kettles on a platform at a higher level than the size box of the slasher, so that the liquid will fall by gravity to the size box, thus enabling the tender to obtain a supply when required. In other cases, where the size kettles are at the same level or at a lower level than the slasher, force pumps have to be provided for supplying size to the size box. Fig. 5 shows the customary style of size kettle. It consists of a cast-iron body, to which is bolted a cover carrying a lid that can be raised by a handle in order to insert the materials. At the foot of the kettle is inserted the pipe c_4, carrying a valve c_5, through which the size can be drawn. The paddle,

or stirrer, in the usual construction, consists of a shaft l on which are mounted arms, or blades, l_1. The stirrer is rotated by power, which is transmitted through a short, horizontal

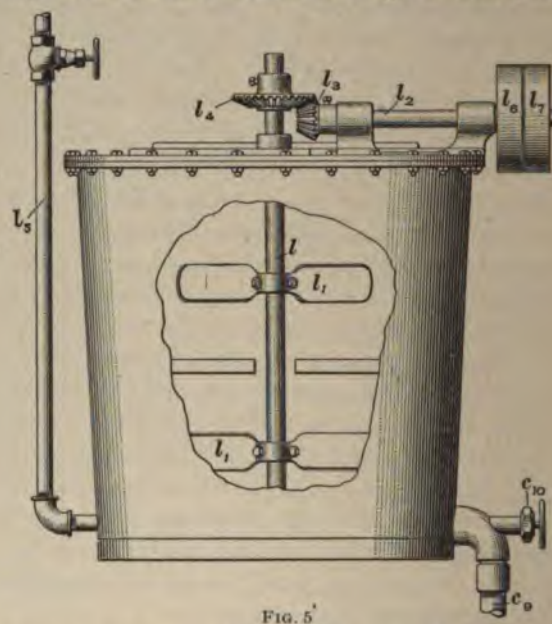


FIG. 5

shaft l_2 and bevel gears l_3, l_4 to the vertical shaft l. In the bottom of the kettle is a coil of perforated copper pipe, through which steam can be blown into the size from the steam pipe l_5. These coils, as well as those of the size box of the slasher, should be so constructed that the steam after passing through the valve is admitted to the coil at opposite points, thus preventing size percolating into the coils and partly blocking the apertures. In some cases, coils are omitted from the bottom of the kettle and the pipe l_5 opens directly into the kettle. It is claimed for this method that the steam, being blown into the size in

TABLE I

Diameter Inches	Capacity Gallons
33	100
37	160
42	250
48	360

this manner, stirs up the size and prevents its collecting on the bottom of the kettle as it sometimes does when coils are used. The driving pulleys l_6, l_7 are usually 9 inches in diameter and are driven by a 2-inch belt. The shaft of the stirrer revolves about 100 revolutions per minute. These kettles are usually made in four sizes, in cast iron, as shown in Table I.

CYLINDERS

13. The **cylinders** h, j, Figs. 1 and 2, are made of rolled copper except the heads, which are of steel plate. These heads should be well stayed with iron rods, while the connection of the copper surface to the head should be well made; this is usually accomplished by shrinking an outer ring over the head. The smaller cylinder j is usually either 4 or 5 feet and the larger cylinder h either 6 or 7 feet in diameter. Each is provided with a manhole, h_1, j_1, Fig. 1, through which access to the interior can be obtained by removing the cover, while valves, known as *atmospheric*, or *back-pressure*, *valves*, are provided at h_8, j_8, by which a collapse of the cylinder is prevented when the steam condenses and a partial vacuum is produced, as is the case whenever the steam is shut off. Each cylinder is carried on roller bearings in order to reduce the amount of friction as much as possible. The bearings for the cylinder h are shown at h_3, h_4, and h_5, Fig. 2, while those for the cylinder j are shown at j_3, j_4, j_5. Cylinders are not usually driven positively but are rotated by the pull of the yarn as it is drawn through the machine; arrangements, however, can be, and usually are, adopted in case of using fine yarns or a small number of ends, by which the cylinders are positively driven.

14. Steam Connections.—The steam connections for the cylinders are shown in Fig. 6. The pipe f, in addition to the branch pipe f_1 for the size box, also has connected to it a branch pipe f_6 that conveys the steam to the two cylinders. By means of the valve f_7, the steam may be shut off from the cylinders independently of the size box, while the valve f_8 checks the flow of steam to both the cylinders and size box.

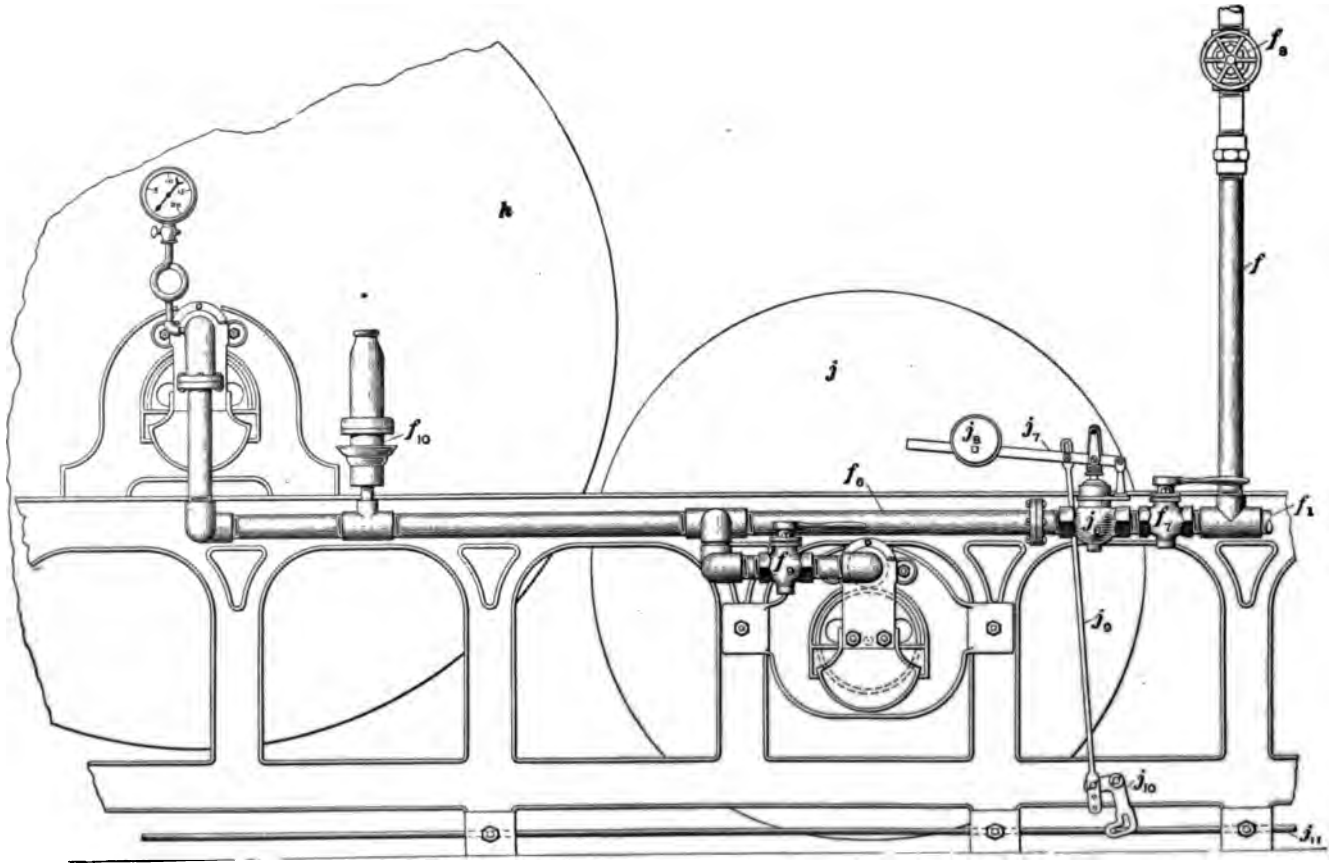


Fig. 6

Another valve f_9 controls the steam for the smaller cylinder j, while the safety valve f_{10} may be regulated to blow off at any desired pressure. Arrangements on the slasher automatically shut off the steam from both cylinders when the slasher is stopped. Referring to Fig. 6, the valve j_8 has connected to it a lever j_7 that carries a weight j_9. Connected to the lever j_7 is a rod j_6 that is connected to a lever j_{10} operated by the starting rod j_{11}. When the driving belt of the slasher is shipped to the tight pulley, the starting rod j_{11} is moved to the left, which, acting through the lever j_{10}, raises the rod j_6 and lifts the lever j_7, thus admitting steam to the cylinders. When the machine is stopped, by the driving belt being moved to the loose pulley, the starting rod j_{11} moves to the right, allowing the weight j_9 to force down the lever j_7 and close the valve j_8.

It is not advisable to admit steam at too high pressure to the cylinders, owing to their immense surface and light construction, and also on account of the fact that a high pressure of steam means a high temperature, which would tend to burn the yarn on the surface of the cylinders. Reducing valves are therefore provided in cases where live steam is used, so that the pressure of the steam will be reduced to less than 15 pounds. The pressure used depends on the work being slashed. In some machines, exhaust steam is used, which is of course at a low pressure and does not require the use of a reducing valve.

The steam that rises from the boiling size in the size box and also the moist air produced by the drying of the yarn on the cylinders is quite appreciable in quantity, and if some arrangement were not provided to carry this from the slasher room, the atmosphere would become detrimental to satisfactory work. To provide for this, the steam is taken away either by natural or mechanical draft. In the former case, the slasher is usually covered with a wooden or metal hood, and a flue connected to the upper part of this hood and carried out of the mill. In case mechanical draft is used, hoods are generally placed over the large cylinder and over the size box, and fans driven by power used to carry off the

moist air. The hoods used in such cases are shown in position over the large cylinder and the size box in Fig. 2.

15. Method of Removing Condensation Water.—If the cylinders are allowed to stand for some time without having any steam conducted to them, the steam that has previously been introduced will condense, forming water. This water if allowed to accumulate would be detrimental to the good work of the cylinders; consequently, all slashers have arrangements attached to the cylinders by which the

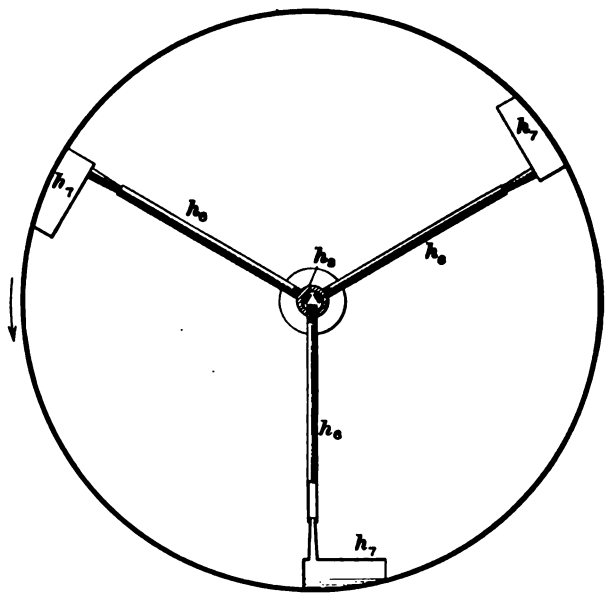


FIG. 7.

condensation water may be removed. The method adopted on the slasher under description is shown in Fig. 7. On the opposite side of the cylinder to that on which the steam is injected are placed pipes h_6, Fig. 7, that run from buckets h_7 to the cylinder shaft h_5, which at this end is enlarged and hollowed out. As the water forms in the cylinder, it collects near the bottom and is scooped up by the buckets h_7 revolving with the cylinder; these carry it around until the

pipe that is attached to each bucket assumes a nearly vertical position, when the water will run down the pipe and be deposited in the hollow shaft h_9, from which it flows to a steam trap. This method of removing the water of condensation is employed in both the large cylinder h and the small cylinder j.

One point that should be noted here is that on both sides of the cylinders perfectly air-tight connections must be made to the revolving cylinders, and yet these connections must be so made that steam can be admitted on one side and condensation water flow out on the other. This is accomplished as

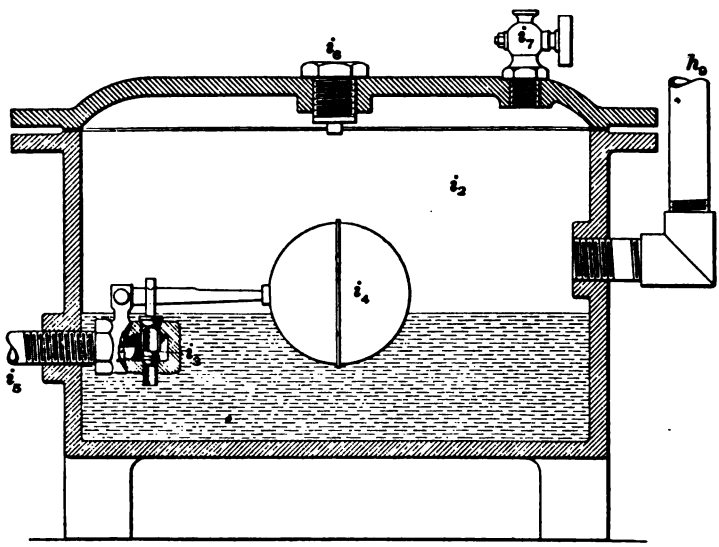


FIG. 8

follows: The shafts that support the cylinders are enlarged and hollowed out at each end; the exhaust pipes at one end and the steam pipes at the other fit into these hollow portions, while packing is introduced to make the connections perfectly tight. This packing that is placed between the shaft and the pipes will, of course, cause a slight friction, but it is not sufficient to produce any unsatisfactory results.

A view of the steam traps to which the condensation water is conveyed from the cylinders is shown in Fig. 8; they are

also shown at i, i_1, Fig. 1. The pipe h_9, Fig. 8, is connected at one end to the cylinder shaft and serves to conduct the water to the chamber i_3 of the steam trap. The valve i_3 is automatically opened and closed by means of the water raising or lowering the float i_4, respectively. For example, when sufficient water has collected in the trap to raise the float, the valve i_3 is lifted from its seat, allowing the water to flow out through the pipe i_5; then as the water falls in the chamber i_2 the float drops and forces the valve firmly on its seat. The float is so regulated that at no time can the valve be open when the surface of the water is below the opening of the pipe i_5, since in this case the steam would be ejected. The water is drained off by the pipe i_6 to any suitable place. An atmospheric valve i_8 is also provided on the trap in order to reduce the difference in pressure between the air pressure on the outside and the vacuum that is formed when the steam in the trap condenses, while a blow-off cock i_7 is introduced that may be opened when the steam is first admitted to the cylinder, thus allowing the air in the chamber i_2 to escape as the steam enters.

It should be understood that different makers of slashers adopt different systems of construction for the various parts, and thus it will be found that all slashers do not have the method of removing the condensation water from the cylinders here described; yet the principle of each is the same, and if the construction of one is understood there should be no difficulty in tracing the workings of another.

HEADSTOCK

16. Split Rods.—The **headstock** of a slasher comprises practically all the parts situated in front of the cylinders. The first parts that call for a description are the **split rods** m, m_1, m_2, m_3, m_4, Fig. 2, that are inserted in place of the lease bands. The band that first appears at the front of the machine is, of course, the one inserted in the creel between the beams a_1 and a_2; the rod m is inserted in its place, and thus in this instance divides the warp into two

equal sheets, all the yarn from the bottom beams being above the rod, while all the yarn from the top beams comes below the rod. When the second band appears, the rod m_1 is inserted in its place, and the band removed; this rod divides the ends of the beam a_1 from the ends of the beams a_3, a_5. As the third band appears the rod m_4 is inserted, which will divide the ends of the beam a_3 from the ends of the beams a_4, a_6. The rod m_3 is inserted in the place of the fourth band and divides the ends of the beam a_2 from the ends of the beam a_5, while the rod m_5 is inserted in place of the fifth band and divides the ends of the beam a_4 from the ends of the beam a_6. In this manner the warp is divided into sheets that are arranged in the same order as that stated in describing the manner of gathering the yarn from the section beams, the sheets from the three top beams being beneath the sheets from the three bottom beams.

17. Expansion Comb and Drag Roll.—From the split rods, the yarn passes to the **expansion comb** *n*, Fig. 2, which divides it into from 300 to 500 groups of ends, preferably with the group in each dent containing only one end from each section beam, and never more than two from each beam. In this manner the sheet of warp is effectually separated into its original condition of individual threads. Another object of the expansion comb is to guide the yarn on to the loom beam in such a manner that the outside ends will just lie within the beam heads and not be crowded, which would cause a hard ridge at both ends and be detrimental to good weaving. It is necessary, therefore, to regulate the expansion comb each time that a loom beam with a different space between heads is run on the slasher.

The expansion comb used on the slasher is similar in construction to the expansion comb found on the warper and needs no detailed description. There is no standard number of dents per inch for these combs, the range being from 7 to 11, according to the counts of yarn intended to be run and whether the slasher is intended for a small or large number of ends.

The **drag roll** r serves to pull the yarn forwards from the size rolls. This roll has two or three layers of cotton cloth wrapped around it, in order to assist it in gripping the yarn and also to prevent the yarn being cut by the measuring roll p and the guide roll r_1 coming in contact with the drag roll.

18. Friction Drive for Loom Beam.—The size and squeeze rolls in the size box revolve at a constant speed and consequently pull forwards the same number of yards during each minute. The drag roll is geared to take up just the amount delivered by the size rolls. The number of revolutions of the loom beam in a given period must constantly decrease, owing to its diameter being increased by the yarn wound on it. The yarn must be wound on the beam at a constant speed to correspond to the rate at which it is delivered by the drag roll. In order to meet this requirement, the beam instead of being driven positively is driven by friction so arranged that as the pull exerted on the yarn by the loom beam tends to increase as the beam increases in diameter, the friction drive will yield and allow sufficient slippage to prevent the loom beam being driven any faster than is necessary to take up the length of yarn delivered by the drag roll.

A view of the system adopted on the slasher under description is shown in Fig. 9. The loom beam s consists of the usual barrel, carrying a head s_1 at each end and having arbors similar to s_2. One arbor of the beam is inserted in a hole in the adjustable shaft s_3, while the arbor on the other end of the beam is inserted in a hole in another adjustable shaft carried at that side of the slasher. Setscrewed to the arbor s_2 is an arm s_4 that is in contact with a stud s_8 carried by a plate s_6 fastened to the shaft s_3. Thus, if the shaft s_3 revolves it will act through the plate s_6, stud s_8, and arm s_4 and turn the beam s. The collar s_7 limits the motion of the shaft s_3 to the left, while any motion to the right is prevented by the arbor s_2 projecting to the end of the hole in s_3.

The manner in which the shaft s_3 receives its motion is as follows: A gear t that is positively driven revolves loosely

on cast-iron sleeves t_1, which are mounted on the shaft s_3 in such a manner that they must revolve with it, although they can be moved longitudinally on the shaft. Bolted to the sleeves t_1 are thin steel disks t_2, both faces of which are covered with heavy flannel t_3. Revolving loosely

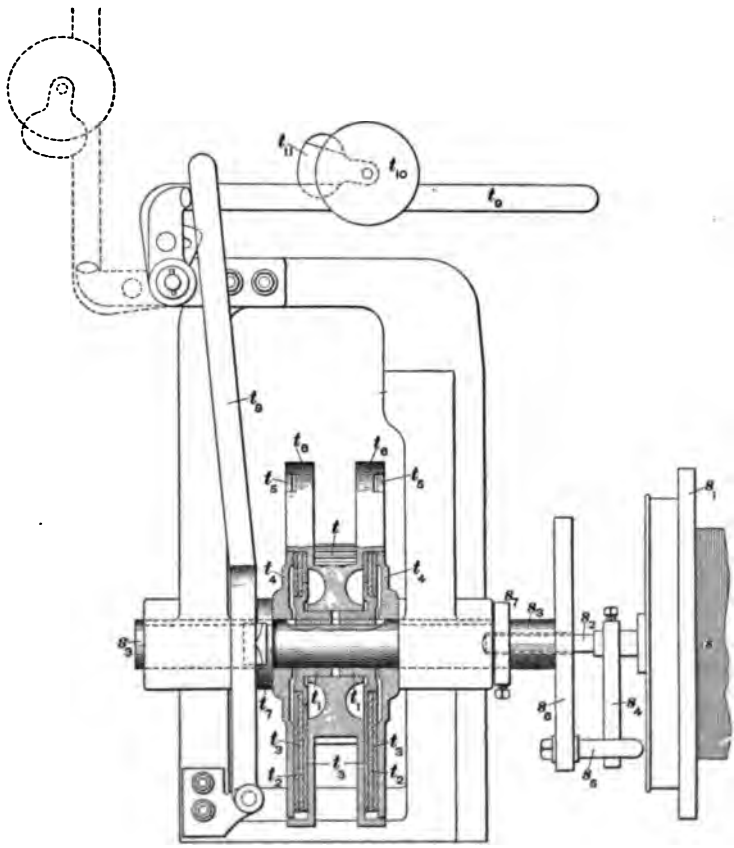


FIG. 9

on the shaft s_3 and outside of both the sleeves t_1 are plates t_4 on which are cast lugs t_5 that fit into the plates t_6, which are a part of the gear t; consequently, the gear t together with the plates t_4, t_6 are positively driven, but since these parts are loose on the shaft s_3, no motion will be given

to the loom beam unless some connection is made between the plates and the friction surface caused by the flannel fastened to the steel disks t_2. Working loosely on the shaft s_3 is a collar t_7 that is in contact with the lever t_8, which is acted on by the lever t_9 carrying the adjustable weight t_{10}. The slots in the plates t_4 into which lugs t_5 on the outside plates t_4 fit are made sufficiently deep to allow the plates t_4 to be forced against the friction flannel; consequently, if the weight t_{10} acts through the levers t_9, t_8, and collar t_7 to force the outside plate t_4, with which the collar comes in contact, against the friction surface, it will tend to move the gear t, together with the left-hand sleeve, toward the right, bringing four frictional surfaces to bear on the steel disks t_2. This action will cause the sleeves t_1 to revolve, being driven by the plates t_4, t_5 through frictional contact with the flannel fastened to the steel disk t_2. As the sleeves t_1 are fastened to the shaft s_3, this will cause the beam to revolve. It should be understood that during the winding of the beam the speed of the shaft s_3 is never equal to that of the gear t, since the beam only revolves at a sufficient speed to take up the yarn, and any additional speed that the gear t may have is lost between the friction surfaces.

When starting a beam, the weight t_{10} is adjusted to give the correct tension on the yarn, but during the filling of the beam it may be found necessary to make additional adjustments of this weight in order to meet the requirements. It will be noticed that the weight is made double, there being an addition t_{11} to the principal circular weight t_{10}. In case that it is desired to make very slight adjustment, this weight may be thrown from one side to the other as required; if it is desired to remove the friction entirely, the lever t_9 may be thrown up and made to assume the position shown by the dotted lines in Fig. 9.

On some slashers the friction drive consists only of two frictional surfaces, instead of four as shown in Fig. 9, while the tension is regulated by means of a hand wheel instead of levers and weights. The principle involved, however, is the same as that described in connection with Fig. 9.

19. Beam Pressers.—Although the friction arrangement for driving the loom beam tends to lay the yarn on the

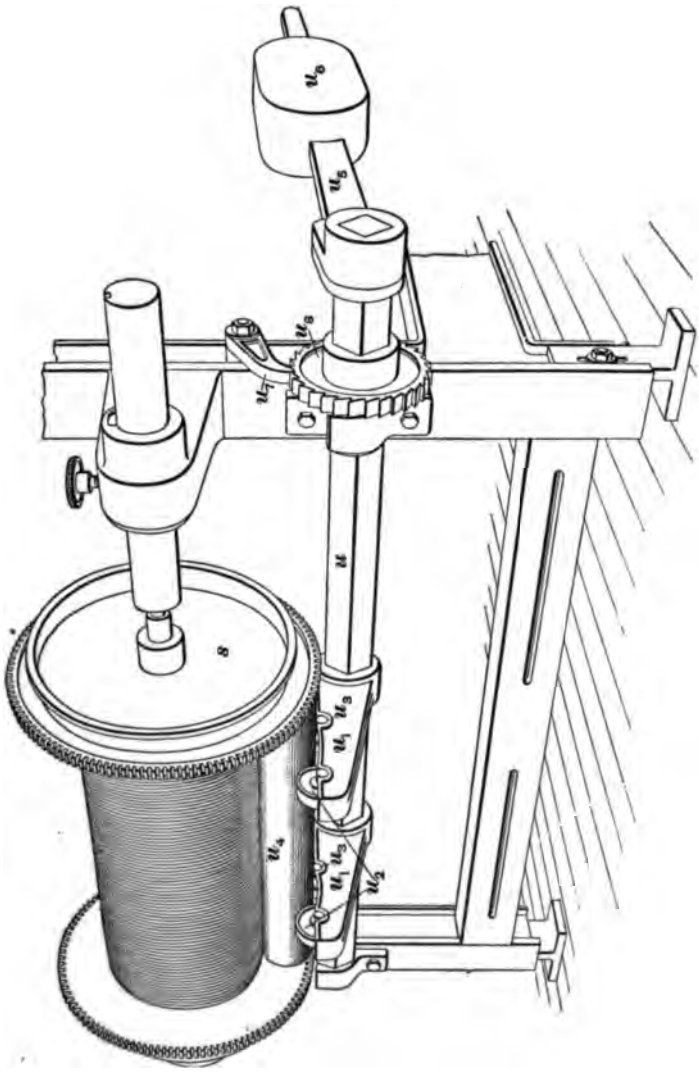


FIG. 10

beam in a compact form, yet in order to further insure a firm, hard beam being made, it is the custom to apply to

slashers an arrangement known as a **beam presser,** which serves to press each layer close to the preceding one. There are various forms of these pressers applied to the slasher, the simplest one consisting only of a lever acting on a roll in such a manner as to keep the roll constantly pressed against the yarn on the beam. Such an arrangement is shown in Fig. 10. A shaft u that extends from one side of the slasher to the other and is situated beneath the loom beam carries two arms u_1, each of which supports two bowls u_2, u_3, on which rests a roll u_4 that is in contact with the yarn on the loom beam s. In order to insure the best results, the length of this roll u_4 should be exactly the same as the distance between the flanges of the loom beam. To one end of the shaft u is attached a lever u_5 that carries an adjustable weight u_6. By moving this weight out or in on the lever u_5 any desired pressure of the roll u_4 may be brought to bear on the yarn as it is wound on the loom beam s. As the diameter of the loom beam is constantly increasing, due to the yarn being wound on it, the beam presses down the roll u_4 and at the same time turns the shaft u and raises the weight u_6. During this action, the pawl u_7 slides over the back of the teeth of the ratchet gear u_8, but does not prevent in any manner the action of the roll u_4 on the yarn. The object of this pawl and ratchet is simply to hold the weight in position when doffing the loom beam, or in case it is necessary for any reason to lift the weight and bring the roll u_4 out of contact with the yarn.

20. The presser arrangement described is somewhat deficient, owing to the fact that the roll is not always in contact with the yarn at the extreme edges, as, for instance, when a beam is being run that has a space between its flanges slightly in excess of the length of the roll. To overcome this defect, rolls are sometimes made in two parts and contain a spring that serves to separate these parts in such a manner that the ends are always in contact with the flanges on the beam. The ends of the two parts that come in contact with each other at the center of the beam are made

with alternate projections and recesses, so that the projections on one roll fit into the recesses on the other. By this means, when the two rolls are extended by the action of the spring, the yarn at the center of the loom beam will still be under the action of the rolls.

There have also been introduced various forms of patented pressers, the one shown in Fig. 11 (*a*), (*b*), and (*c*) being the one adopted on the slasher that has been described, Fig. 11 (*a*) being a sectional elevation taken along the center line of the front elevation, Fig. 11 (*b*), while Fig. 11 (*c*) is a plan view of the carriage v with the rolls removed. It consists of a shaft u extending from one side of the slasher to the other and carrying the ratchet gear u_8, lever u_9, and adjustable weight u_6 similar to the presser shown in Fig. 10. Extending from nearly the central point of the shaft u is a single arm u_1 that supports the carriage v, which, in turn, supports three sets of bowls u_2, u_3, u_5. The back and middle sets of bowls support a roll u_4, while the front and middle bowls support an expanding roll u_{10} that consists of an internal shaft on which are mounted two tubular rolls. The front bowls u_5 rest in swivel bearings, to which are connected rods v_1, v_2 that are attached at their other ends to a lever v_3 supported by a shaft to which is attached the bell-crank lever v_4. When the beam is first started, the front bowls u_5 are in the position shown in Fig. 11 (*b*) and (*c*); consequently, as these bowls revolve toward the front of the machine they tend to force the tubular rolls toward the flanges of the beam and keep them in this position while the beam is being filled. As the roll that rests between the back and middle sets of bowls is constantly being pressed against the yarn wound at the center of the beam, the action of the two rolls combined insures a firm and compact beam.

As the diameter of the beam is increased by the yarn wound on it, the carriage, together with its several parts, is forced down until the upper arm of the bell-crank lever v_4 comes in contact with a pin v_5 on the arm v_4. Any further downward motion of the carriage will cause the lower arm of the bell-crank lever to swing to the right and turn the

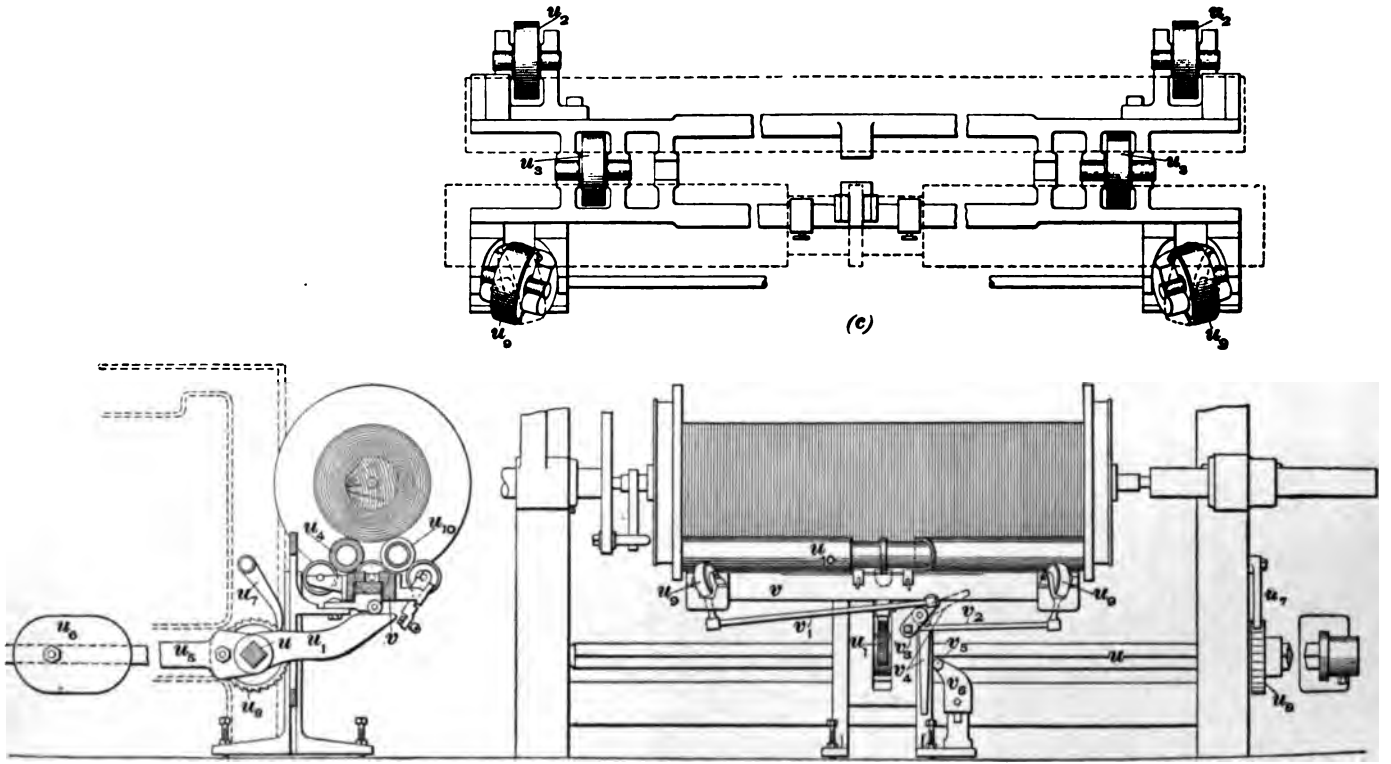


FIG. 11

stud on which it is mounted, together with the lever v_3. This motion of the lever v_3 being communicated to the swivel bearings, through the connecting-rods v_1, v_2, causes the position of the front set of bowls to become reversed and occupy the position shown by the dotted lines in Fig. 11 (c), with the result that the tubular rolls now move in toward the center of the beam. The arm v_4 should be so set that the pin v_5 will come in contact with the bell-crank lever when the beam is nearly full, thus preventing the tubular rolls expanding beyond the beam flanges and cutting the yarn.

GEARING

21. Fig. 12 shows a plan of the gearing of the slasher. The tight-and-loose pulleys w, w_1 are mounted on the cross-shaft w_2, which carries at its other end the change gear w_3. The gear w_3 drives, by means of a carrier, the gear w_4 on the drag roll r. On the shaft of the drag roll with the gear w_4 is a bevel gear w_5 that drives another bevel gear w_6 on the side shaft w_7. At the other end of this side shaft are two bevel gears w_8, w_9 that drive, respectively, the bevel gears w_{10}, w_{11} on the size rolls d_1, d. On the shaft w_7 is also placed a pulley w_{12} that drives, by means of the belt k_2, the pulley k_1 on the shaft carrying the fan k. The gear w_4 drives the gear t of the friction motion. The side shaft together with the bevel gears driving the size rolls are introduced in order to relieve the strain on the yarn that would occur if the size rolls had to be revolved by the drag roll pulling the yarn over them. Cotton yarn, if stretched when wet, loses much of its elasticity; consequently, the method is adopted of driving the size rolls through a side shaft at such a speed that they will deliver the same amount of yarn as that taken up by the drag roll. In some cases the stretch of the yarn between the size rolls and the drag roll, which amounts to approximately $\frac{1}{2}$ per cent., will cause the yarn to be slack. In this case an additional layer of cotton cloth is wound around the drag roll to increase its diameter. When it is desired to drive the cylinders positively, in order to still further reduce

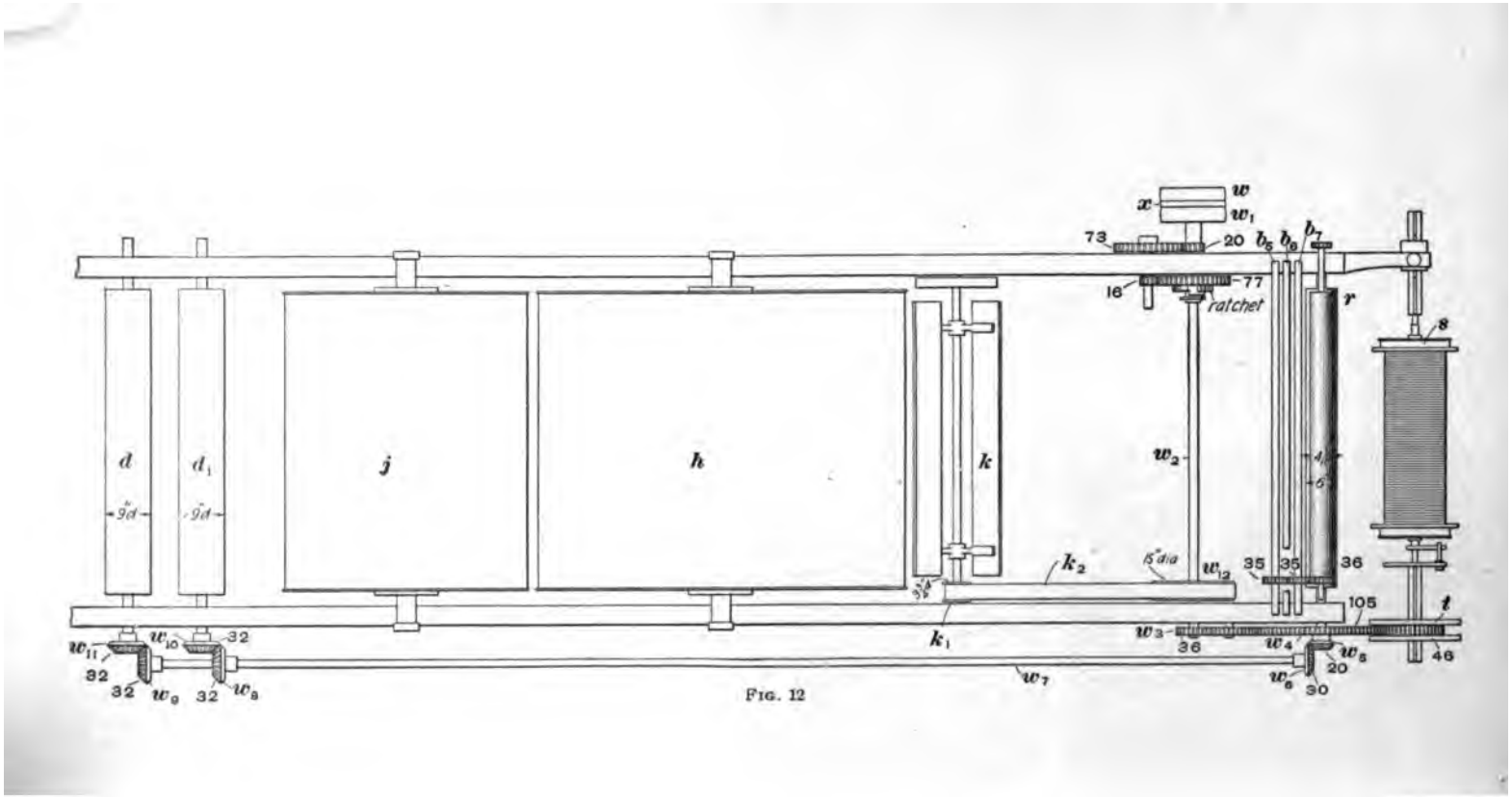

w
x
w1
73
20
b5
b6
b7
16
77
ratchet
r
8
d
d1
9"d
j
h
k
w2
4"d
6"d
k2
15"d/a
w12
35
36
105
t
k1
w3
w4
w5
w7
w6
30
46
w11
w10
32
w9
w8

FIG. 12

the strain on the yarn, a train of gears is inserted between each cylinder and the side shaft.

22. In some cases the shaft w_2 that carries the driving pulleys w, w_1, instead of having the gear w_3 attached to it, carries a cone that, by means of a cone belt, drives another cone, the gear w_3 being on the end of the shaft carrying the driven cone. The object of driving the different parts of the slasher through cones is to make it possible to change the speed of the machine more quickly and conveniently than by gears. When a different quality of work is run on the slasher it may be necessary to change its speed. For example, when running a warp of a small number of ends that is to be sized lightly, the slasher may be run very quickly; while, on the other hand, if it is desired to run a heavy sheet of warp or one that requires considerable size, the yarn will require a longer time for drying, and consequently the machine must be run more slowly. When the cone drive is not adopted, the driving pulleys or one of the gears must be changed to accommodate the speed of the slasher to the work being run; but in case the cone drive is adopted, it is simply necessary to move the cone belt along the cones until the desired speed is obtained.

23. **Slow Motion.**—Since it is necessary at times to greatly reduce the speed of the slasher without stopping it entirely, as, for instance, when piecing up broken ends, a slow motion is introduced. A view of this motion is given in Fig. 13. The tight pulley w is setscrewed to the shaft w_2; consequently, when the belt is on this pulley the slasher is receiving its maximum speed. In case it is desired to set the slow motion in operation, the belt is shipped to the slow-motion pulley x, which is on a sleeve x_1 that works loosely on the shaft w_2, the loose pulley w_1 working loosely on this sleeve. Setscrewed to the sleeve x_1 is the hub x_2 of the gear x_3, which engages with a gear x_4 on a short stud x_5. At the other end of this stud is a gear x_6 that engages with the gear x_7 loose on the shaft w_2. Attached to the gear x_7 is a pawl x_8 that engages with the ratchet gear x_9, which is keyed

to the shaft w_2. A spring x_{10} that is sprung around the hub of the ratchet gear x_8 by engaging with the pins on the pawl, causes the pawl to become engaged with the ratchet

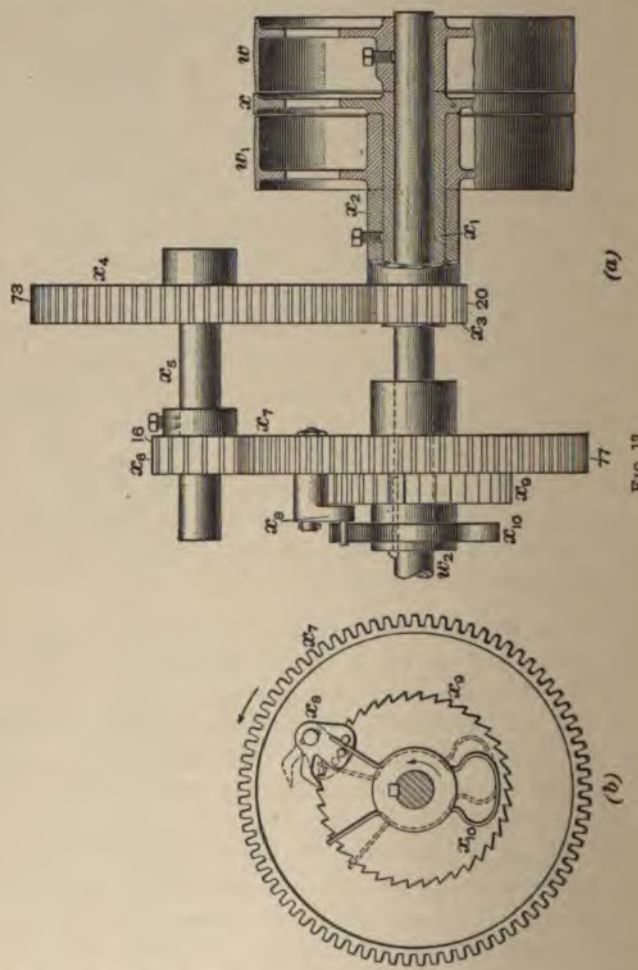


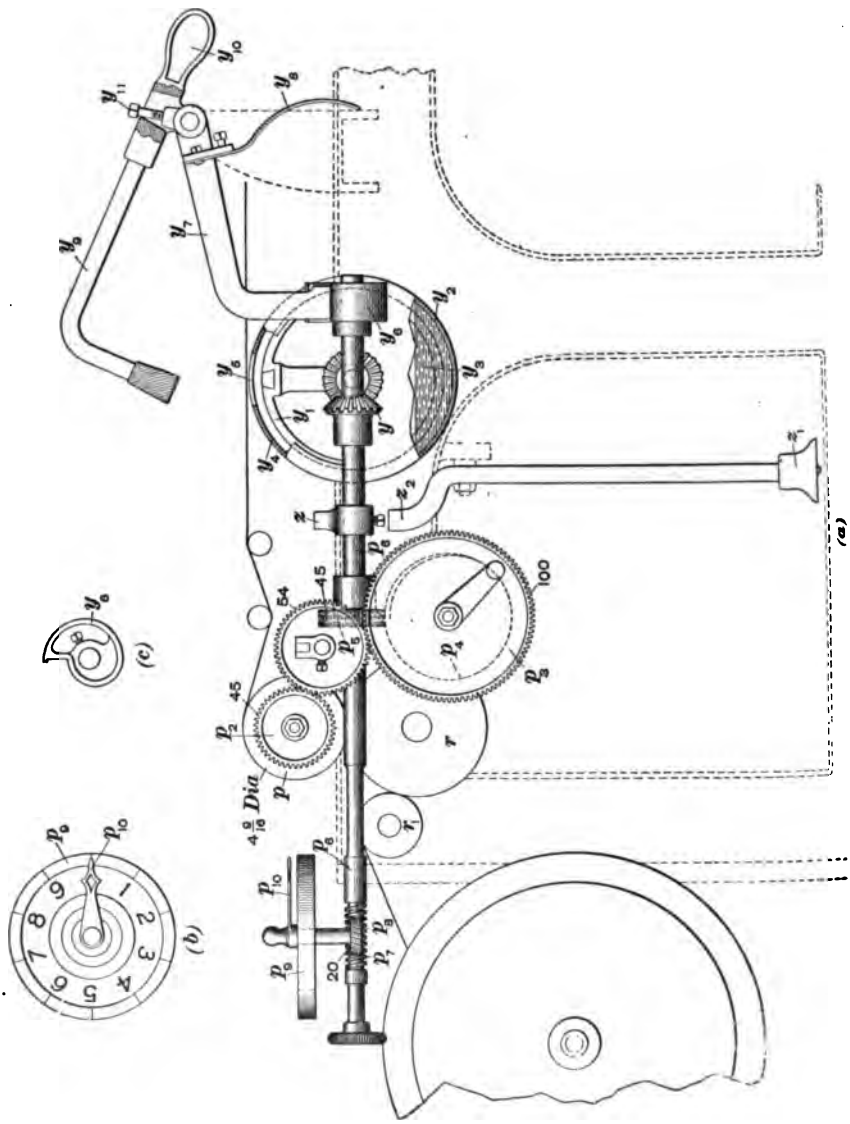
FIG. 13

gear when the belt is on the slow-motion pulley, but throws the pawl out of contact when the belt is on the tight pulley. Thus, in the former case the pawl assumes the position

shown by the full lines in Fig. 13 (*b*), while in the latter case it assumes the position shown by the dotted lines.

The explanation of this action is as follows: When the belt is on the tight pulley, the shaft w_8 is driven directly with the pulley and revolves in the direction shown by the arrow in Fig. 13 (*b*). The spring x_{10} being sprung on the hub of the ratchet gear will tend to revolve with the gear and the shaft, but its connection with the pins on the pawl will prevent its doing so. It will, however, move sufficiently to cause the lower part of the pawl to swing to the left and become disengaged from the ratchet. On the other hand, when the belt is on the slow-motion pulley, the gear x_7 is being positively driven in the direction shown by the arrow, carrying the pawl around with it. In this case the pins on the pawl press against the end of the spring, which causes the lower part of the pawl to swing to the right until it becomes engaged with the ratchet. The gears between the slow-motion pulley and the ratchet gear x_8 are so arranged that the machine is driven at about one-eighteenth of the speed it attains when driven by the tight pulley.

24. Measuring Motion.—The measuring motion of the slasher is operated primarily from the measuring roll p, Fig. 2. The details of this motion are shown in Fig. 14. Resting on the drag roll r and driven by frictional contact with it is the measuring roll p, which is $4\frac{9}{16}$ inches in diameter and carries at one end a gear p_2 of 45 teeth. The gear p_2 drives, by means of a carrier, the gear p_3, which is on a short stud with the single worm p_4. The worm p_4 drives the gear p_5 on the shaft p_6. At the front end of this shaft is a worm p_7, driving the gear p_8 on a stud that passes through the indicating disk p_9 and carries at its upper end the finger p_{10}. The disk p_9, shown in plan view in Fig. 14 (*b*), is supported by a bracket attached to the framework of the slasher, but the finger p_{10} revolves with the stud on which it is mounted, and thus indicates the length of yarn run. On the slasher the amount of yarn run is spoken of as so many cuts, a cut indicating any number of yards—usually between 40 and 60—


(a)
(b)
(c)
Dia
54
45
100
20

that may be determined on, and the finger p_{10} indicates on the disk p_9 the production of the machine in cuts. One revolution of the shaft p_6 represents one cut run on the slasher; consequently, since there are 20 teeth in the gear p_6 and this gear is driven by a single worm, the stud, together with the finger p_{10}, will make one revolution while twenty cuts are being run. As there are only ten numbers on the disk p_9, it follows that each number represents two cuts run; that is, if the finger is set at the zero point on the disk and the slasher started, when the finger has moved to 1 on the disk two cuts will have been run. On some slashers the gearing is so arranged that the finger moves one number each time a cut is run, while the disk is divided into twenty divisions.

The carrier gear interposed between the gears p_2, p_3 is held in position by a short lever, by raising which the carrier gear may be readily moved out of contact with the two gears. This arrangement provides a means of setting the cut marker by turning the handle on the gear p_3 without rotating the measuring roll.

25. Cut Marker.—During the weaving process, each time a cut has been woven the cloth is severed from the rest of the warp; it consequently becomes necessary to provide some means by which the weaver may know when the desired length has been woven. This is provided for by introducing on the slasher a mechanism known as a **cut marker** that stamps on the warp yarn a mark at each complete revolution of the shaft p_6, Fig. 14. Referring to this figure, on the shaft p_6 is a bevel gear y that engages with another bevel gear on a short shaft that carries a cast-iron pulley y_1. A pan y_2 that partly encircles the pulley y_1 is fastened to the framework of the slasher and contains a dye y_3. An outer casing y_4 is placed over the top of the dye pan and at the point y_5 is cut away in order to expose a portion of the pulley y_1. A cam y_6, shown in elevation in Fig. 14 (c), is setscrewed to the shaft p_6 and acts on a lever y_7 that is kept constantly pressed against the face of the cam by means of the spring y_8. On the stud to which

the lever y_7 is attached is a screw y_{11} that is in contact with the hammer y_8, which is weighted at the end y_{10} in order to overbalance its forward end.

The action of these parts is as follows: As the shaft p_6 revolves it turns the pulley y_1 by means of the two bevel gears, thus causing the face of this pulley to be constantly smeared with dye. The cam y_9 also revolves and thus forces upwards the lever y_7 until the point at which the cam is cut away comes in contact with the lever, when the spring forces down the lever with a quick motion, at the same time causing the screw y_{11} to throw down the forward end of the hammer y_8 so that it will come in contact with the face of the pulley y_1. As the yarn is between the hammer and the pulley, it will be marked with the dye, and since the weighted end y_{10} of the lever immediately forces up the forward end, the contact with the warp is as brief as possible. This is desirable, since if the pulley should be in contact with the warp for any appreciable length of time, a long smear would be made instead of a mark only about 2 inches long as is desired.

Other parts of the cut marker that should be noticed are the casting z and bell z_1. The casting z is setscrewed to the shaft p_6, and as it revolves with the shaft its point comes in contact with z_1 and rings the bell. This casting is generally set in such a position that it will cause the bell to ring when about half a cut has been run, thus indicating to the tender that another cut is about to pass the drag roll.

CALCULATIONS

26. The calculations in connection with the slasher are not now of so much importance as formerly when a great variety of change gears were used to obtain the different lengths of cuts. In connection with any calculations dealing with the production of a slasher, it should be understood that a certain percentage must be deducted from the calculated production in order to make allowance for stoppages due to such causes as changing the loom beams or changing the sets

at the back of the slasher. This allowance will of course vary with different classes of yarn, but for ordinary work, such as plain white warps, about 35 per cent. will be found to be a fair allowance.

EXAMPLE 1.—Referring to Fig. 12, find the speed of the drag roll if the driving shaft makes 250 revolutions per minute and the change gear has 36 teeth.

SOLUTION.— $\frac{250 \times 36}{105} = 85.714$ rev. per min. Ans.

EXAMPLE 2.—Find the number of yards slashed per minute if the drag roll makes 85.714 revolutions per minute.

SOLUTION.— $\frac{85.714 \times 6 \times 3.1416}{3 \times 12} = 44.879$ yd. Ans.

EXAMPLE 3.—Find the speed of the size rolls when the driving shaft makes 250 revolutions per minute and the change gear has 36 teeth.

SOLUTION.— $\frac{250 \times 36 \times 20 \times 32}{105 \times 30 \times 32} = 57.142$ rev. per min. Ans.

EXAMPLE 4.—Find the number of yards per minute that pass the size rolls when they make 57.142 revolutions per minute.

SOLUTION.— $\frac{57.142 \times 9 \times 3.1416}{3 \times 12} = 44.879$ yd. Ans.

It will be noticed from the above calculations that the amount of yarn taken up by the drag roll exactly equals the amount passed forwards by the size rolls. This, of course, is necessary in order to keep the yarn at the proper tension between these two points.

EXAMPLE 5.—Referring to Fig. 12, find the speed of the fan when the driving shaft makes 250 revolutions per minute.

SOLUTION.— $\frac{250 \times 15}{3.75} = 1{,}000$ rev. per min. Ans.

EXAMPLE 6.—Referring to Fig. 13, find the speed of the driving shaft when the belt is on the slow-motion pulley, if this pulley is driven 250 revolutions per minute.

SOLUTION.— $\frac{250 \times 20 \times 16}{73 \times 77} = 14.232$ rev. per min. Ans.

From the above calculation it will be seen that the slow-motion arrangement makes a very appreciable difference in the speed of the machine.

EXAMPLE 7.—Referring to Fig. 14, find the length of yarn that passes the measuring roll between successive cut marks.

SOLUTION.— $\frac{4\frac{9}{16} \times 3.1416 \times 100 \times 45}{12 \times 3 \times 45 \times 1} = 39.815$ yd. Ans.

EXAMPLE 8.—Considering the 45-tooth gear on the end of the measuring roll to be the change gear, find the constant for the measuring motion.

SOLUTION.— $\frac{4\frac{9}{16} \times 3.1416 \times 100 \times 45}{12 \times 3 \times 1} = 1{,}791.693$, constant. Ans.

NOTE.—The constant for the measuring motion in this make of slasher is usually considered as 1,800, and will be so considered in these calculations.

EXAMPLE 9.—If the constant for the measuring motion is 1,800, what change gear will be required to give 64-yard cuts?

SOLUTION.— $1{,}800 \div 64 = 28.125$; a 28 gear would be used. Ans.

EXAMPLE 10.—If the constant for the measuring motion is 1,800, what length of cut will a 35 change gear give?

SOLUTION.— $1{,}800 \div 35 = 51.428$ yd. Ans.

VARIATIONS IN CONSTRUCTION

27. It should be understood that the descriptions given do not cover all types of slashers. Various methods of applying size to cotton warps have been or now are in use. In the early days of manufacturing, it was applied by hand with brushes, and the warps fanned or hot irons passed underneath them until dry. A later method, which is still in use to some extent, was to make a warp in the form of a chain and pass it through boxes of size, afterwards drying it on cylinders; this was called **ball**, or **chain, sizing.** Still another method, to which the name of **Scotch dressing** was originally given, was to warp the yarn on section beams and pass it through a dressing machine, the size being applied by brushes with a reciprocating motion; no lease was taken in the machine. In this machine, the section beams were placed at each end, while the weaver's beam was formed in the center. A later development of this machine was known as the **tape-dressing machine,** so called because the warp after being run through leasing harnesses was sized in *tapes*, or groups of ends, and passed to the loom

beam in this form. These machines were not used long, as they were unsuccessful. Substantially, the slasher of the present day combines the best points of its forerunners.

As previously stated, a single-cylinder slasher is sometimes used instead of a double-cylinder machine. This type of slasher is generally found in those mills where it is important to economize space and where a large production is not required. A single-cylinder slasher does not produce as much work as a double-cylinder slasher, on account of having less drying area, which necessitates running the warp through the machine more slowly in order to satisfactorily dry it. The same applies to machines with small cylinders.

The type of slasher known as the *hot-air slasher* is used occasionally. In almost all respects this machine is the same as the cylinder slasher except in the drying arrangement; the yarn in a hot-air slasher is dried by being passed through a hot-air chamber that contains many coils of piping, through which steam circulates at a high pressure. Since the chamber is closed, the air within reaches a high temperature, and as the sheet of warp yarn is guided through it by means of rolls so as to pass between the coils of pipe, it emerges in a dry state.

28. When sizing colored warps on the slasher it is not advisable to run all the colors through one size vat, as the colors that are not fast or the darker colors would tend to run and discolor the white or lighter colors. It is customary, therefore, to have two size boxes and arrange for the white or light fast colors to pass through one box, while the dark or fugitive colors pass through another. Owing to these size boxes being some little distance apart and the yarn passing to the top of the large cylinder from the size boxes, the two sheets of warp are kept separate for a distance of about 10 feet. In passing through this space they become partly dried, and thus before the two sheets come in contact the colors have lost the tendency to run.

Some manufacturers approve of the use of brushes to lay the fibers and improve the feel and appearance of the sized

warp, especially in mills using very fine yarns or on colored work where a distinct weave effect is required in the fabric. The brushes are applied to the damp warp immediately after it leaves the size roll in the size box; they are circular, covered with a good grade of long bristles, and by rotating at a suitable speed effect the object just described. The yarn then passes to the cylinder in the ordinary way. Below each brush is another that runs in a trough filled with water. It comes in contact with the upper brush and serves to keep the latter clean.

Slashers can be constructed so as to make two beams at the front of the machine instead of one, by having one headstock placed above another. This is not advisable, except where beams with a small number of ends are required, such as top beams for fancy work. In such cases if only one loom beam is run at a time, the small number of ends passing through the slasher will be found to be a disadvantage to good work, in addition to greatly increasing the cost per pound for slashing. By passing sufficient ends through the slasher for two loom beams and adopting the arrangement mentioned for filling two beams at one time, these disadvantages are greatly lessened.

MANAGEMENT AND OPERATION

29. The process of slashing warps is one of the most important in the mill, and should be in charge of thoroughly competent men. One hour's carelessness or one hour's work by an incompetent slasher tender will cause a month's worry and annoyance to a weaver, in addition to causing bad work, seconds, and lessened production in the weave room; and as one slasher supplies from three hundred to five hundred looms with warps, its importance is easily seen.

30. Creeling.—At the end of each set **creeling** takes place, namely, removing the empty section beams from the creel and replacing them with full ones, and at this time opportunity is also taken to wash the rolls and clean certain

parts of the machine. When a set is finished and full section beams must be placed in the creel instead of the empty ones, the hoist and track is used to bring these into place. The ends of warp are guided around the beams and tied to the sheet of warp from the former set. A weight is slung over the beam barrels to avoid the overrunning of section beams. During the running of a set stoppages should be made only for the purpose of doffing the loom beams as they are filled, since better work can be done by continuous running.

A set of section beams usually makes from fifteen to twenty loom beams, depending on the diameter of the loom-beam heads, and it ought to be the object of the slasher tender not to stop the slasher during the running of the set more frequently than is necessary to doff these beams, so as to maintain the same conditions continuously and to avoid variations in the sizing or the drying of the yarn. In some mills, it is customary to start a new set each morning and finish it the same day. In order to do this it is necessary that the slashers should be driven by a small independent engine or electric motor, so that they can be run during the noon hour and overtime at night, if necessary. This also gives facilities for working the slashers overtime when necessary to maintain the supply of warps for the looms.

31. Doffing.—It is customary to run the yarn on the loom beam, not only until it is filled level with the heads, but also almost an inch outside the heads, coning the ends gradually by contracting the expansion comb, so that the yarn will not fall over the beam heads or become entangled or slack. The object of this is, of course, to get as much yarn on the beam as is possible. The greater the length on the loom beam, the longer the loom can run without changing the warp, thus increasing the production and reducing the cost of drawing in the warps. If the yarn otherwise contained on fifteen loom beams could be placed on thirteen by placing some yarn above the level of the heads of the loom beams, the expense of drawing in two warps would be saved on each set. A certain amount of waste is

also avoided by this means. It is more customary to practice this in mills on plain or heavy fabrics than in mills on fancies or fine fabrics, where the contraction in the width of the warp might be detrimental to satisfactorily starting the warp in the loom.

Just before doffing the beam in the slasher it is customary for the tender to make such preparations for stopping as putting in lease bands, if he desires to test whether the leases are all right, placing these in such a position that they will appear at the front almost exactly where the warp will be cut off when doffing. The slasher is then stopped and the beam slung out by means of the hoisting tackle (if this is used; if not, the beam is taken out by hand and placed on a truck); a new loom beam is placed in the frame and the sheet of warp attached to it by means of a wooden rod that fits into a groove in the barrel and under which the yarn is firmly held. A comb, such as is shown in Fig. 15, is then struck through the completed warp, in order to keep the ends straight, and the cap of the comb tied securely, after which the sheet of warp is cut with a pair of shears and the ends of the warp on the full loom beam knotted in three or four bunches. After the expansion comb is adjusted so that the sheet of warp will fit the new loom beam accurately, as previously explained, the slasher is operated for a short period with the driving belt on the slow-motion pulley until the tender sees that a good beam is being made and all is running satisfactorily, when the belt is shipped to the tight pulley and the machine operated until it is time to again doff a beam.

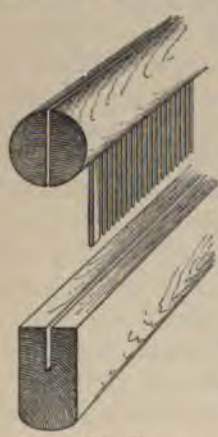


FIG. 15

32. The cylinders should be kept hot enough to dry the yarn satisfactorily but not so hot as to make the yarn brittle. Pressure of steam practically regulates this, as a higher pressure of steam means a higher temperature. It is an accepted

rule among good slasher tenders that better work can be done with a machine running slowly and the cylinders at a moderate temperature than by having a high temperature and running the yarn through very quickly. Yarn should never be run on the beam unless perfectly dry. If damp it tends to mildew and rot, making bad weaving and spoiling the goods. The pressure of steam used in the cylinders varies from 4 to 15 pounds. A high pressure of steam is used when coarse yarn is being slashed; when a large percentage of size is applied; for a warp with a large number of ends; and when a slasher is being run at a high speed, even with a medium number of yarn or a medium sheet. Low pressure is used for fine yarns, thin sheets, or slow-running machines. About 8 pounds is the usual pressure.

Cylinders must be kept clean. New cylinders should be rubbed with tallow to prevent the yarn sticking; it is also advisable to treat old cylinders in this way once in a while, especially where there is not much softening material used in the size.

The admission of size to the size boxes requires watchfulness so as to keep about the same quantity in the box at all times and to frequently admit a new supply in small quantities. As the size is heated, while in the box, by means of steam injected through the steam pipe, the condensation of the steam constantly tends to reduce the consistency of the size, so that if long intervals elapse between admitting fresh size the mixture is apt to become too thin, and later, when new size is admitted, it becomes too thick, causing a variation in the percentage placed on the yarn. It is important to carefully regulate the amount of steam admitted to heat the size, by means of a valve provided for this purpose. The immersion roll must be kept low enough to give a good supply of size to the warp. The lower the roll is placed, the longer the yarn remains in the size, and consequently, the greater amount it absorbs.

The spots of color forming the cut marks should be noted to ascertain if there is sufficient color imprinted on the warp to make the mark easy of observation to the weaver and

yet not so much that it will soak through two or three layers of the warp when the yarn is wound on the loom beam and cause the weaver to doubt which is the correct mark, besides discoloring the cloth. Cut markers are sometimes placed at the back of the slasher, in order to avoid this difficulty by drying the cut mark before it reaches the beam.

The winding of the yarn on the beam at the front of the machine must receive constant attention, not only to see that the sheet of warp is spread evenly by means of the expansion comb, so as to form a smooth surface across the entire beam without ridges, and that the yarn fits snugly against the beam heads, so as to avoid making too soft or too hard edges to the warp beam, but also to watch the tension drive, so that it shall be at all times great enough to wind the yarn tightly on the beam but not sufficient to put so much tension on the threads as to weaken or break them. A well-made beam should be perfectly hard and round, especially near the heads. A soft end to a beam is a great nuisance to the weaver.

The section beams in the creel require watching, so as to detect as early as possible the breakage of any end, which is indicated by a lap on the beam, which becomes more prominent as the other ends unwind. This lap should be promptly cut off and the broken end allowed to pass forwards and placed in proper position in the comb at the front of the machine.

When repairing broken ends, just before and after doffing the beam, or performing other operations in connection with the slasher, it is advisable to run the machine with the belt on the slow-motion pulley. If the steam valve to the cylinder is not automatically closed at the same time that the belt is moved to the slow-motion pulley or to the loose pulley, the tender must shut off the steam and watch the warp on the cylinder to see that it does not become burned.

When the slasher is stopped at night it is important that the size rolls and squeeze rolls should be washed with cold water, the immersion roll raised out of the size, and the squeeze rolls raised out of contact with the size rolls; the steam is also shut off from the cylinders.

In order to divide the warp into tapes, or groups of ends, to afford easy facilities for filling the expansion comb at the front of the machine, a *striking comb* with as many teeth as there are teeth in the expansion comb is sometimes pushed through the sheet of warp just before it enters the size box at the beginning of a set and held there while a few yards of warp pass through it. This causes the warp to be sized in tapes, and one tape is placed in every space in the expansion comb. This, of course, is done before the split rods are inserted. The striking combs used for this purpose differ in the number of teeth to the inch, there being usually three sizes to each machine. If a set of section beams is intended for narrow loom beams a comb with few teeth per inch is used, so as to divide the sheet into fewer tapes and thus take up less width in the expansion comb at the front. If it is intended to make wide loom beams, a striking comb with more teeth per inch is used, so as to give more tapes, which will occupy more space in the front comb.

SIZE

MATERIALS

33. Many points distinguish a good size mixing from a poor one; the leading qualification for a suitable one is its adhesive property, since it is useless to size warps if the substance falls off at the loom. Other requirements are good color, uniform consistency, and the property of leaving the yarn smooth, tenacious, and pliable, even when heavily sized. The ingredients should also be selected with a view to the processes through which the cloth must pass after weaving. Some of the chemical properties of certain ingredients are detrimental to the *converting* of cloth, as in bleaching, dyeing, printing, and other succeeding processes. The number and variety of sizing substances render it impossible to adequately describe the properties and uses of each, and mention will be made of those of principal importance only.

Sizing materials may be divided into five classes: **(*a*) starches**, or the adhesive substances, forming the body

of the mixing; (*b*) softening substances, used to avoid harshness in the dried warp and preserve the softness and pliability of the yarn; (*c*) weighting substances, used in medium and heavy sizing to add the weight that the adhesive substances cannot give; (*d*) antiseptics, or substances that tend to destroy micro-organisms and vegetable life, and thus prevent the growth of mildew or the decomposition of the size; (*e*) miscellaneous ingredients, used for coloring and other purposes.

34. Starches.—Considering the first group of substances, the principal ingredients are corn starch, potato starch (sometimes called farina), wheat flour, sago flour, or rice flour. In the United States, corn starch and potato starch are the principal adhesive substances used, some mill men preferring one, some another, usually the cheaper one being adopted. Either is convenient for use in light sizing, but each requires a softener to counteract the harshness that it gives to the warp when used alone. Wheat flour is very largely used in heavy sizing, as it is more glutinous and fixes weighting substances on the yarn better than any other material; it also does not tend to make the warp as harsh as starches of other grains; on the other hand, it has a tendency toward mildew and does not give as bright a color to the warp as some of the other materials.

35. Softeners.—Perhaps the most useful material for a softener is tallow, which is the refined fat of animals, beef or mutton tallows being the principal ones used for this purpose. The various kinds of wax are also useful; for example, Japanese wax, a vegetable product that is a light, hard substance of a slightly yellow color, and paraffin wax, which is a clear and semitransparent product obtained in the manufacture of mineral oils. A high melting point of wax used for sizing is desirable, 110° F. being a suitable standard. Other softeners sometimes used are glycerine, castor oil, palm oil, and soap. Many varieties of softeners are sold under a patented name used as a trade mark.

36. Weighting Substances.—Weight-giving substances are not much used in American mills; of those used china clay, sometimes called kaolin, is perhaps the most valuable. This is a white or bluish-white clay found only in a few countries, which if carefully mined and washed should be free from grit, smooth to the feeling, dead white and uniform in color, and having great affinity for moisture.

Among other substances sometimes, but not often, used for weighting are sulphate of lime, sulphate of magnesia, sulphate of soda, and sulphate of baryta. Chloride of magnesium (which is often called antiseptic, though it possesses no antiseptic properties) and other metallic salts are also sometimes used. This chloride is obtained in Germany, and in addition to being naturally a heavy substance, has the property of attracting moisture to itself.

37. Antiseptics.—Antiseptics are substances that tend to destroy vegetable life and micro-organisms and thus prevent the decomposition of the size or the growth of mildew. The antiseptic substance that is most largely used in size mixing is known as muriate, or chloride, of zinc. This is also valuable as a weight-giving substance, for since it is a metallic salt, really consisting of zinc dissolved in muriatic acid, it has a high specific gravity. Another antiseptic is carbolic acid, but this is not so largely used as the muriate of zinc.

38. Ingredients Used for Coloring and Other Purposes.—Among the miscellaneous substances used for tinting the size in case it is desired to imitate piece goods or to produce what are known as *shot effects* are aniline dyes of various colors. For tinted warps, a blue dye is sometimes used in very small proportions for the purpose of correcting a tendency to yellowness in the size mixing; the blue dye changes it to a bluish white.

Sometimes soda is used with the idea of preventing iron stains. Turpentine is often used in small quantities to cut the softening materials and cause a proper blending of the constituents of the mixture; from 1 gill to 1 pint per 100 gallons of water is sufficient. It is found to be especially

useful in sizing Egyptian cotton yarn, which carries a wax or fatty matter on its surface in sufficient quantities to repel the application of liquid size.

MIXINGS

39. An important matter in connection with size is the proportion of the ingredients to be used and the method of mixing them. Perhaps no topic connected with cotton manufacturing admits of such a variety of opinions or is practiced in so many ways as size mixing. Almost every mill has a different mixing, and the same mill will frequently have several mixings in use for various purposes. The reason for this is that the managers of each mill have found by experience what they consider the size mixing best suited to their class of goods and to the climatic and atmospheric conditions under which they are made. One mill may also desire to put on a rather larger percentage of size than another, even on the same class of goods, in order to gain weight, or the superintendent of one mill may have made a special study of sizing, in order to make a mixing as economical as possible and at the same time satisfactory, while another superintendent may have a wasteful system of size mixing. The result is that there are hundreds of size mixings in use, and it consequently is rendered very difficult, if not impossible, to give standard mixings that will be recognized as satisfactory by the majority of mill men.

Although American size mixings vary, they are few compared with size mixings in Europe, where the warps are weighted anywhere from 5 to 200 per cent. and where the number of mixings is correspondingly multiplied in variety, especially as many sizing ingredients enter European size mixings that are not used in America to any great extent.

In considering a size mixing, the proportion of each of the five classes of size materials should be considered with relation to the quantity of water used. Perhaps the best plan is to always reduce the ingredients of any mixing under consideration to the basis of 100 gallons of water and to consider

the quantity of dry starch, softening substances, weighting substances, antiseptic substances, and miscellaneous ingredients that are used to this 100 gallons of water. Also, the following points should be considered: Ply warp yarn can be woven with very little size, in some cases even without size. Single warp yarn of medium number in a cloth of light sley and pick can be woven with a minimum of size. A warp that has to be woven in a fine reed, or in other words, one that contains a large number of ends per inch, requires a stronger size than one with a small number of ends per inch, since in the former case the ends are so close together that the friction on them is largely increased. The same applies to a cloth with a heavy pick, that is, a large number of picks per inch; in this case the warp passes so slowly through the loom that it is subject to chafing of the reeds and harnesses for a much longer time than a warp in a light-pick cloth and consequently has to be sized more heavily. A warp of fine, hard-twisted yarn, especially Egyptian yarn, requires a stronger mixing than a medium yarn, as it has not the same tendency to absorb size as a yarn of medium counts spun from American cotton. A very coarse warp, being loosely twisted, tends to fray in the loom more easily than a yarn of medium counts and twist, and this requires a stronger size. The expression *strong size*, or *mixing*, implies one containing a large percentage of sizing material in proportion to the amount of water.

40. It is impossible to give a specific minimum percentage of size to be used on all warps or the minimum strength of a size mixing that will apply to all fabrics. The size for each widely different style of goods must be considered separately. The following fundamental principles, however, govern all cases: (*a*) A size mixing is weakest and is applied with the smallest percentage for medium yarns, say from number 20s to 40s, and for a cloth of light sley and pick; (*b*) if the cloth is woven with a heavy sley and pick, even with the same numbers, the mixing must be made stronger; (*c*) if the yarn is very fine, the mixing must also

be made stronger; (*d*) if the yarn is very coarse but very light-twisted, the mixing must be made stronger.

41. The following table gives approximately the weights of starch and softening materials that ought to be used to each 100 gallons of water on various numbers of warps from 10s to 100s for pure sizing only:

TABLE II

Counts of Yarn	Light Sley and Pick		Medium Sley and Pick		Heavy Sley and Pick	
	Starch Pounds	Softening Pounds	Starch Pounds	Softening Pounds	Starch Pounds	Softening Pounds
10s to 25s	40	5	45	6	50	6
25s to 30s	30	4	35	5	40	5
30s to 40s	35	4	40	5	50	6
40s to 60s	45	5	50	5	65	7
60s to 80s	50	6	65	7	80	10
80s to 100s	65	7	80	10	90	12

To each of the above mixings other ingredients may be added for special purposes; for example, turpentine, not more than 1 quart and often only 1 gill to 100 gallons of water; aniline blue, from $\frac{1}{4}$ to $\frac{1}{2}$ ounce to 100 gallons of water; alum, not more than 4 pounds to 100 gallons of water; Yorkshire gum, about 2 pounds to 100 gallons; soap, about 1 pound to 100 gallons; blue vitriol, not more than 1 gill to 100 gallons. Only the turpentine and the aniline blue are of much use, and then only in special cases.

42. It should be understood that climate, atmospheric conditions, the location of the weave room—whether on the ground floor or on the upper floor of a mill—the character of the goods being made, and even the class of help that weave the goods will necessitate modifications of any size mixing. The best advice that can be given is to select from the above table the size mixing that most nearly approaches the conditions of the special case to be considered, and after slashing a few beams and finding

whether they weave satisfactorily or not, either strengthen or weaken the size or add more or less adhesive materials until the best mixing is obtained for the purpose, remembering that it is better to err on the side of making the mixing too strong rather than to run a number of warps so soft that they will not weave. More starch in proportion to the amount of water stiffens the size and a heavier percentage can be obtained. More softening materials in proportion to the amount of starch and water make the warp more pliable and remove the harshness found in some cases.

Where potato starch is used instead of corn starch, less weight of starch is required to obtain the same results, as potato starch is better in quality than corn starch, although usually it is higher in price and consequently not so largely used.

Economy in the use of size materials is largely a matter of boiling. A comparatively weak size mixing can be made to do the work of a stronger mixing if it is well boiled, while at the same time better results are obtained in the weave room from a well-boiled size than from one that is badly cooked.

43. When considering the question of sizing for weight the same remarks as to varying the proportions of the ingredients according to the numbers of yarns and the sley and pick hold good, but in this case the mixing has to be made considerably stronger, not only by an addition of a larger proportion of starch materials, which necessitates a larger proportion of softening materials, but in some cases by the addition of weight-giving materials. The following mixings are given as examples of medium and heavy sizing:

To apply 50 per cent. to the warp, that is, $\frac{1}{2}$ pound of size for each pound of warp yarn: Water, 100 gallons; wheat flour, 320 pounds; china clay, 150 pounds; tallow, 40 pounds; chloride of magnesium, 3 gallons; muriate of zinc, 1 gallon; soda, 5 pounds.

For heavy size, say 100 per cent., that is, 1 pound of size for each pound of warp yarn: Water, 100 gallons; wheat

flour, 560 pounds; china clay, 560 pounds; tallow, 130 pounds; chloride of magnesium, 20 gallons; muriate of zinc, 10 gallons; soda, 10 pounds; aniline blue, ½ ounce.

For a mixing that will give from 150 to 200 per cent. on the warp the following materials should be used: Wheat flour, 560 pounds; china clay, 1,600 pounds; tallow, 1,600 pounds; soap, 20 pounds; soda, 30 pounds; chloride of magnesium, 40 gallons; muriate of zinc, 20 gallons; aniline blue, ¾ ounce. In this latter case barely sufficient water to liquefy the mixture would be used. The water in which the flour has been steeped, together with the chloride of magnesium and the muriate of zinc, probably would not exceed 100 gallons in all.

In making a heavy size mixing, a different method is employed than in making pure size mixing. The wheat flour is sometimes steeped alone for 3 weeks, at the end of which time the muriate of zinc is added to it, together with the soda, and the mixture heated. The clay, tallow, and other ingredients are mixed separately in the size kettle and boiled, after which the two compounds are mixed together and boiled.

DRAWING IN AND REEDING

44. After the warp yarn has been slashed and wound on the loom beam, it must be taken to the drawing-in frame and the ends drawn through the heddles of the loom harnesses and then through the reed. After these operations are completed the warp is ready to be placed in the loom and woven.

45. Harnesses.—The harnesses employed in weaving cotton cloth are of two kinds—those with wire heddles and those made from cotton. A view of a harness with wire heddles is shown in Fig. 16 (*a*), an enlarged view of the heddle being shown in Fig. 16 (*b*). The harness, as shown in this figure, consists of a wooden frame to the end pieces of which are attached two steel heddle bars a_1 on which the wire heddles are strung. These bars are usually fastened at one end by means of threaded stretcher hooks and nuts,

while at the other end they pass through slots in the harness frame and are secured by hooks that engage with holes in them. Hooks a_2 are also inserted in the frame to support and stiffen the heddle bars. The wire heddles, Fig. 16 (*b*), are twisted from wire, and in addition to the eyes required at each end for the purpose of threading them on the heddle bars, they also contain an eye at the center, through which a warp end is drawn.

Cotton harnesses, which are employed largely in weaving plain cloth, are made by knitting together a large number of cotton threads in such a manner that two series of loops will be formed, one at the bottom and one at the top. Wooden rods are passed through these loops and the cotton threads

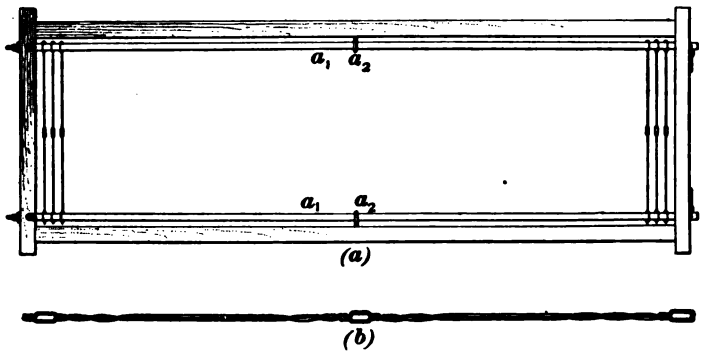


FIG. 16

fastened to them. The twine, which takes the place of the wire heddles, also contains an eye at the center, through which an end of the warp is drawn. The harness twines from top to bottom, including the eye, are from about 10 to 13 inches in length; the eye is usually about $\frac{1}{4}$ inch deep for weaving cotton goods. In order to make cotton harnesses capable of withstanding the friction of the weaving process, it is necessary to size and varnish them; this produces a hard, smooth surface and if well done leaves a pliable harness twine. Faulty varnishing will show itself in several ways: the twine may be swollen, or the eyes closed or turned sidewise to the direction of the warp instead of being open and facing the yarn;

the eyes may be rough; or lumps of size and varnish may be left in them, thus causing the twine to decay quickly or be stiff or sticky. When using harnesses with wire heddles, as many heddles as are required to make the cloth desired may readily be placed on each harness, since these heddles are easily taken off or put on the heddle bars; whereas, the cotton harness cannot be changed, and when made to weave a cloth containing a certain number of ends per inch must always be used for that sley of cloth.

The smallest number of harnesses that can be employed to produce a woven fabric is 2, while in some cases as many as 36 are used. These harnesses when placed in the loom are attached to a mechanism that raises and lowers them, some of the harnesses being up, while others are down. In this manner a division of the warp is made, technically known as a *shed*, through which the filling is passed, thus producing an interlacing of the warp ends with the filling and forming cloth.

46. Drawing-In Frame.—Fig. 17 gives a view of a drawing-in frame with the loom beam, warp yarn, and harnesses in position for drawing in the ends. The drawing-in frame consists of two stands a, a, connected by rods a_2. The loom beam when placed in the drawing-in frame rests in the supports a_3, while the warp is passed over the upper rods a_1 and hangs in front of the frame. Two rods a_4 that are supported by the upper rods connecting the two stands of the frame serve to hold the harnesses directly in front of the warp ends. The operation of drawing in the warp is as follows: The order in which the ends are to be drawn through the harnesses is usually indicated by a draft made by the designer. Fig. 18 shows such a draft. The horizontal rows of squares represent the harnesses, the draft being made in this case for a warp that is to be drawn in on 8 harnesses, while the vertical rows of squares indicate the warp ends, the figures in these vertical rows of squares showing through which harness each end is to be drawn. In drawing in, the operator commences at the right of the warp and of the harness frames, drawing the first end

of the warp through the harness indicated on the first vertical row of squares at the right of the drawing-in draft. Thus, with the draft shown in Fig. 18, the first warp end at the right is drawn through the eighth harness, the next end through the seventh harness, the next end through the sixth harness, the

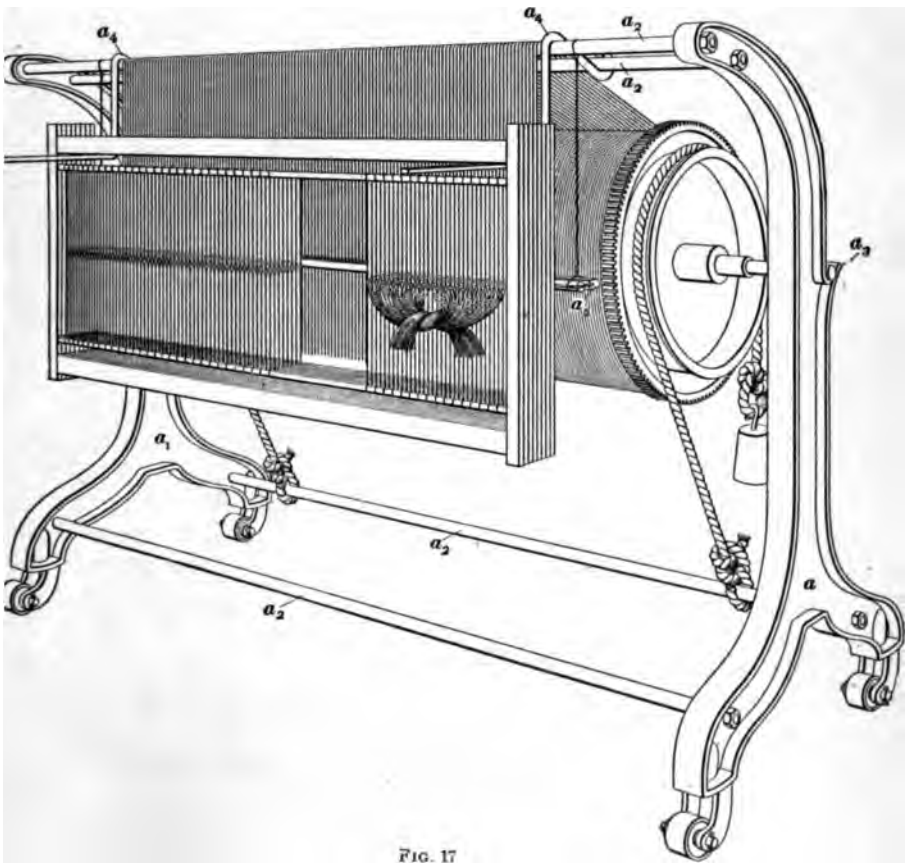


FIG. 17

next through the fifth harness, the next through the eighth harness, and so on until all the ends indicated on the draft have been drawn in, when the operation is repeated a sufficient number of times to draw in the entire warp. When a number of the ends have been drawn through the heddles the

drawer-in divides them into two bunches and ties them in a half knot in front of the heddles, so as to prevent the ends from being accidently pulled out.

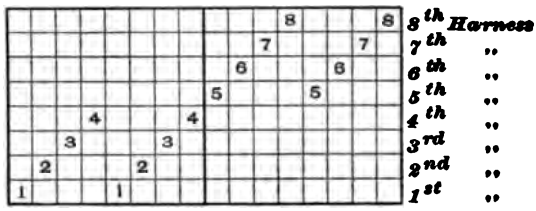


FIG. 18

In drawing in the warp ends a hook, known as a *drawing-in hook*, shown in Fig. 19, is used. Its blade is passed through the heddle eye and the slot at the end engaged with a warp end. As the hook is withdrawn the end is brought with it and thus passed through the eye of the heddle. In drawing in warps, the operator should take the ends in as nearly as possible the same order that they are laid on the beam, since if this is not done the ends will be badly crossed and will



FIG. 19

cause serious trouble at the loom. To facilitate the ends being taken in their correct order, the comb, Fig. 15, that is placed on the warp as the loom beam is taken from the slasher is used, as shown at a_5, Fig. 17. This comb keeps the ends in their original order during the time that the loom beam is being handled between the slasher and drawing-in frame, and also aids the operator in selecting the ends when drawing them through the harnesses.

47. Reeding.—After the warp ends have been drawn through the harnesses it is necessary to draw them through the reed, an illustration of which is given in Fig. 20. Reeds are made by inserting narrow flat strips of steel, known as *splits*, between the top and bottom ribs, the splits being firmly secured to the ribs by means of tarred string that

passes around the ribs and is inserted between the splits. The space between two consecutive splits of the reed is known as a *dent*, and the number of these dents in an inch determines the fineness of the reed. The length of the splits, measured between the ribs, is governed by the class of fabric to be woven and the kind of loom in which it is to be woven; a space of $3\frac{1}{2}$ inches is about right for cotton looms. In drawing the ends through the reed, a hook known as a *reed hook*, shown in Fig. 21, is used. This hook is passed through a dent of the reed and a number of ends, depending on the number of ends to be drawn through this particular dent, are engaged and drawn through the reed as the hook is withdrawn. The hook is then inserted in the next dent and the ends drawn in in a similar manner. The number of ends drawn through a dent of the reed will vary in different cases, and even in the same warp the reeding particulars may call for a different number of ends in different dents. In any case, however, the ends must be taken in

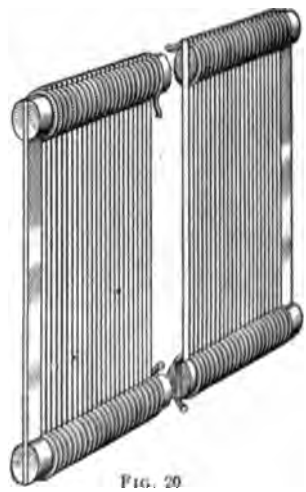


FIG. 20



FIG. 21

the order in which they come from the harnesses, so that they will not be crossed. When reeding the warp ends the operator works from right to left in the same manner as when drawing the ends through the harnesses, and also ties the warp in half knots in front of the reed to prevent the ends being pulled out of the reed.

TWISTING IN

48. After a warp has been nearly woven out in the loom, if the new warp that is to replace it has the same number of ends and is to be woven with the same drawing-in draft, considerable time and labor may be saved by **twisting it in.** When twisting in can be conveniently performed in the loom, the new warp is placed in stands back of the loom and the ends twisted to those of the old warp. This is done by taking, with the right hand, one thread from each of the two warps in the proper order and after laying their ends together turning them around each other with the left hand in such a direction as to remove their twist, after which the two ends are jointly bent back and twisted firmly around that one of the two threads that belongs to the new warp. Each end of the new warp is twisted to the corresponding end of the old warp in this manner, and the new warp is then carefully drawn through the harnesses and reed. While this method of uniting the ends is not strong enough for weaving, it is strong enough to enable the new warp to be drawn through the harnesses and reed without difficulty if care is taken. When twisting in, the operative generally dips his fingers in whiting and oil, in order to enable the threads to be more firmly secured to each other, and also to prevent the ends from cutting his fingers.

49. **Twisting-In Frame.**—When it is not convenient to twist in the new warp in the loom, a frame purposely constructed must be provided for this purpose. This frame, Fig. 22, consists of stands *a* for supporting the warp beam *c*, a stand *b* for carrying the harnesses *d*, and the reed *e*, which is usually tied to the harnesses to hold it securely in place. After a lease *j* has been taken, the old warp is cut out of the loom with a small piece of the woven cloth attached. This cloth is secured to a drum b_1 by means of pins b_2; a ratchet *g* and pawl g_1 prevent this drum from turning and slackening the warp while it is being twisted in. The new warp, having a lease at *k* (or more commonly, in the case of cotton warps,

a comb), is placed in its stands and each end twisted to an end of the old warp at *m*; a strap a_1 and weight a_2 prevent the beam from turning and slackening the warp while twisting it in. After all the warp is twisted, the friction is taken off

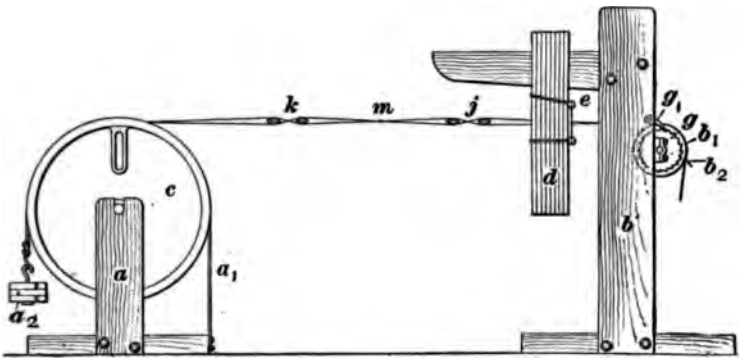


FIG. 22

the beam and the drum b_1 rotated until the new warp is drawn through the harnesses and reed, after which the old warp is broken away. The ends of the new warp may now be knotted loosely in front of the reed and the warp placed in the loom.

CHAIN WARPING

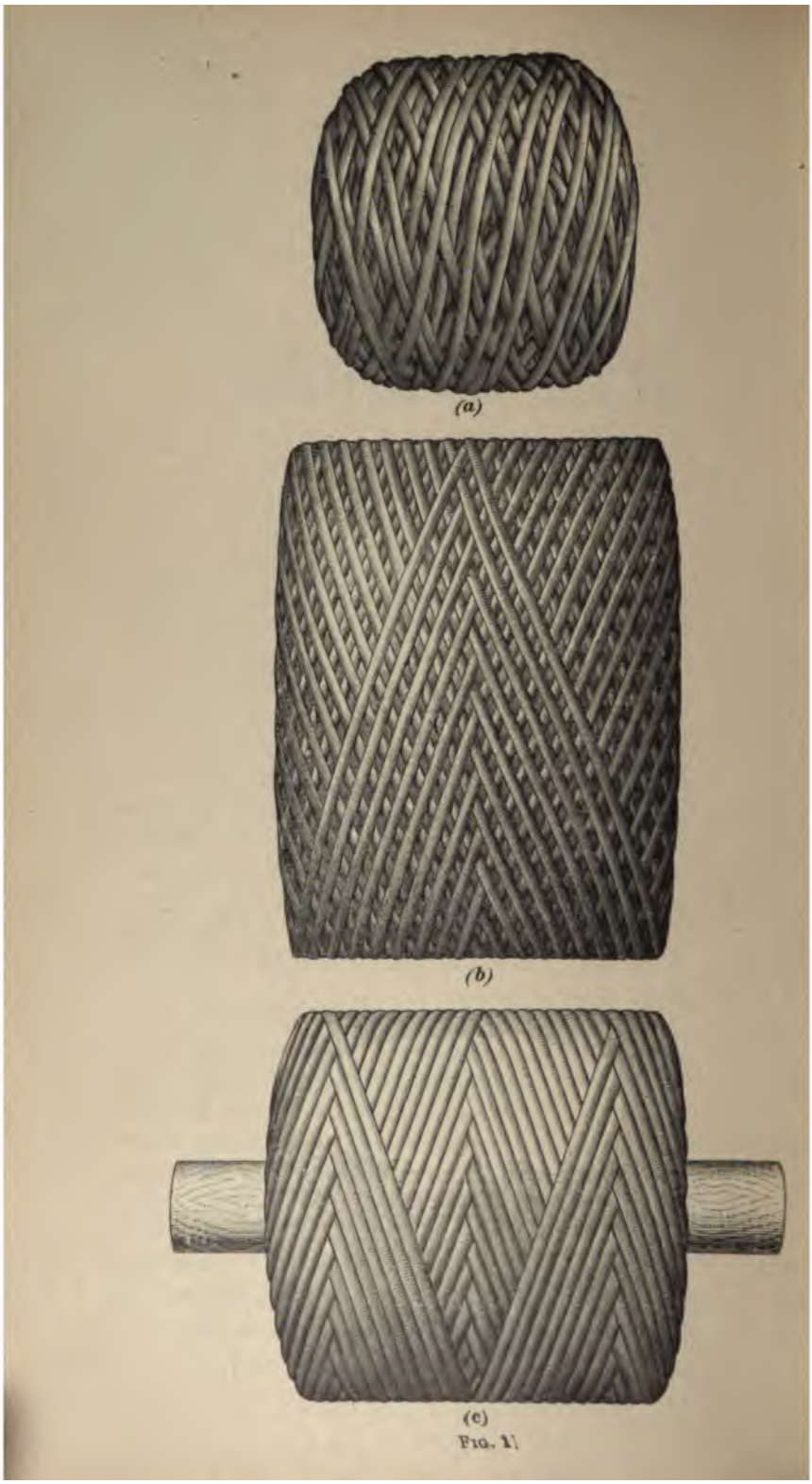
(PART 1)

INTRODUCTION

1. The processes intervening between the spinning and the weaving, in ordinary branches of cotton manufacturing, in order to prepare the warp yarn for the loom are: spooling, where the yarn from the cop or bobbin is placed on spools; beam warping, where the yarn is put up on section beams; and slashing, where the yarn is placed on loom beams. By far the larger proportion of cotton warps are made in this manner, especially where the yarn is both spun and woven by the same firm, and for goods that are woven from warps that are not bleached, dyed, printed, or otherwise treated. Where yarn mills produce warps for sale, and in those mills where yarn is both spun and woven, but where it is the practice to bleach, dye, print, or otherwise treat the warp yarn, an entirely different system of making warps is generally used, known as *chain warping*.

A **chain** consists of a large number of ends of yarn, either single or ply, gathered together so as to form a loose, untwisted rope of yarn of considerable length. Each end in the chain is of the same length, but chains may be made of various lengths. As this form offers, without damage, facilities for transportation that are not possible in the beam-warping system, besides being more convenient and less expensive with regard to freight, it is the method favored by mills producing warps for sale. As it is also the most convenient form in which to bleach, dye, and otherwise treat

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(a)

(b)

(c)

FIG. 1.

yarn, it is the most suitable way in which mills using colored warps can purchase their warp yarn or make their own warps, as the case may be. The makers of ginghams and other colored goods frequently dye and otherwise treat their filling yarns in the chain form, which form is also suited to the requirements of makers of cotton driving ropes and of some other branches of textile work. For these reasons chain warping has increased in recent years.

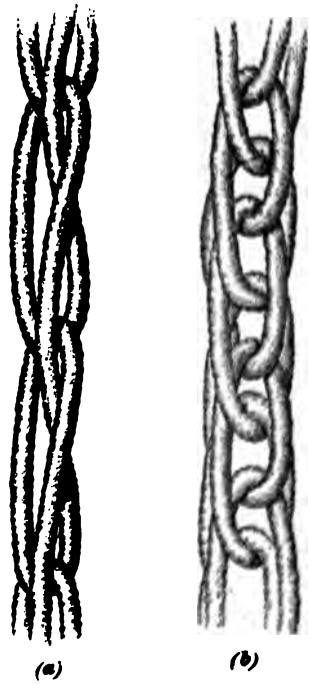


FIG. 2

2. Chains may be put up in bags or they may be balled or linked. When, after warping, the chain is coiled into a round or cylindrical form, it is spoken of as a **ball**; this is the most common method of putting up chains for transportation. A **linked chain** is one that has been arranged to resemble the links of a chain, thus shortening its length, decreasing the risk of damage in transportation, and affording facilities for its suitable handling at future processes. Three styles of balls are shown in Fig. 1 (*a*), (*b*), and (*c*), and two styles of linked chains in Fig. 2 (*a*) and (*b*).

The word ***chain*** is the correct name for all yarn—whether warp or filling, balled or linked—made by the processes of warping described in this Section. The word chain is sometimes misinterpreted, due to the fact that some people consider the term to apply only to that form of chain that is linked and not to the balled form. The term, however, may be properly applied to either form. Since the yarn of which chains are made is generally warp yarn, it is common to speak of chains as warps, as for example ball warps, linked warps, etc.; but this term is not sufficiently comprehensive,

since filling yarn is sometimes put up in chains, to which the word warp cannot correctly be applied. It also tends to confusion, since the word warp is also applicable to the beamed form of yarn. Therefore, in this Section, the word chain will be used as a comprehensive term covering the product of the various processes and machines for warping herein mentioned.

3. Short- and Long-Chain Systems.—Two systems of making chains are in use, known as the **short-chain system** and the **long-chain system.** The short-chain system is the older method and its use is confined almost entirely to yarns intended for the warp of a fabric. The long-chain system is more generally used at the present time for warp yarns and is almost exclusively used for filling yarns that are chained.

The difference between these systems is partly indicated by their names; the short-chain system is used for warps of a limited length, usually only sufficient to fill one loom beam, which is generally less than 1,000 yards, although sometimes slightly greater than this; the long-chain system is used for making chains of much greater length, sometimes as long as 10,000 yards, or even more. The treatment of the yarn, however, is also somewhat different in the two systems. The operations from the spinning or the twisting frame to the completed loom beam in the short-chain system are: (1) spooling; (2) chain warping; (3) bleaching, dyeing, or otherwise treating the yarn; (4) sizing; (5) beaming to the loom beam; (6) drawing-in. This system is seldom used for filling yarns, so that its consideration for this purpose will be ignored.

The long-chain system when used for warp yarns consists of the following sequence of processes from the spinning or the twisting frame to the completed loom beam: (1) spooling; (2) chain warping; (3) bleaching, dyeing, or otherwise treating the yarn; (4) beaming to section beams; (5) slashing to loom beams; (6) drawing-in. The sequence of processes for the treatment of filling yarn in

the long-chain system after the spinning process is as follows: (1) spooling; (2) chain-warping; (3) bleaching, dyeing, printing, or otherwise treating the yarn; (4) quilling on the long-chain quiller.

For special purposes either of these systems may be slightly modified, according to the requirements of the mill in which the yarn is treated or for special styles of goods, but the processes given are those generally used. This affords a ready method of classifying the systems and indicating the differences between them. In either system, minor differences may also exist in the warping process—for example, the chain may be made on different styles of warpers—or the methods of beaming may vary without affecting the general division of the processes into long- and short-chain systems.

4. Spooling.—The spooling process is usually the same whether the yarn that is to be made into a chain is warp or filling, and whether the process is the long- or the short-chain system. The spooler generally used is the ordinary construction of an upright-spindle spooler, which takes the yarn from a mule cop or spinning bobbin and places it on a double-headed spool. It is possible, and in some cases is customary, to use quick-traverse cross-winding machines for the same purpose, in which case the yarn is built up in cylindrical form on a parallel tube without heads. This machine, however, is not used so frequently in the long- or short-chain systems as the ordinary spooler.

CUTS AND LEASES

CUT MARKS

5. As chains are made in various ways, according to the purpose for which they are intended, a knowledge of the uses of chains and of the later processes necessary to convert them into suitable form for use, either as warp or filling, is advantageous, either as a preparation to the study of chain

warping or to those who have charge of chain-warping work, since a knowledge of the reasons for making chains in certain ways increases the possibility of producing suitable chains intelligently. The chief particulars required for making a chain warp are the counts of the yarn, the total length of the chain, and the number of ends in the chain; these, of course, are essential irrespective of other information. Other particulars required under certain circumstances are the number of cuts or leases in each chain and the kind of leases to be taken.

Information regarding the number and length of cuts is only necessary in the case of short chains of warp yarn. Cloth is woven in *cuts*, which should be of the same length when for one style of cloth. To indicate to the weaver when a cut of the desired length has been woven, it is customary to mark the warp in some way. In the case of slashed warps made by the ordinary system of warp preparation, this is done by a marking motion in the slasher, which makes a slight impression of coloring matter at the completion of each cut; but as short-chain warps do not pass through a slasher, being dressed, or beamed, to a loom beam after having been bleached or dyed and sized, it is necessary that the cuts be marked as the chain is made. Since chain warps are dyed, bleached, or otherwise treated, it would not be satisfactory to mark the cuts with coloring matter, such as colored chalk, for the marks would wash or bleach out or be obliterated in the dyeing process. It is customary, therefore, for the operator to tie a loose band of twine around or through the chain at the proper places. These bands pass through the dyeing and other processes without being removed until the yarn arrives at the beaming process, when as the end of each cut is reached, this cut-marking thread is removed and a fresh mark made in such a way that it will be recognized by the weaver—either by the use of coloring matter or otherwise.

Cut marks are not necessary in the case of long chains of warp yarn, since these chains are afterwards beamed to a section beam and then run through the slasher, which is

provided with an arrangement for automatically placing colored marks on the warp at the completion of each cut. Neither are cut marks necessary for long chains of filling yarn, since this is afterwards quilled to shuttle bobbins, where marks of any kind would, of course, be undesirable.

LEASES

6. In the ordinary system of warp preparation, where the warp yarn, after spooling, is passed through the operations of beam warping and slashing, the ends forming the warp pass in a level, even sheet through these processes, maintaining their position with relation to one another until they arrive at the loom beam, whence they can be woven off, without entanglement, in a smooth, level sheet. It is quite different with chain warps, which are formed by collecting the ends into a loose rope, or strand, of yarn. As the chain subsequently is passed through some such process as bleaching, dyeing, sizing, etc., it would be very difficult, if not impossible, to separate the ends afterwards so as to use them for warp or filling, unless some means were adopted for grouping the ends at intervals. This is accomplished by inserting what are called **leases.** (The word is sometimes spelled *leese*, but *lease* is the preferred form.)

An essential feature of all modern methods of making chains is to arrange the ends in a level, even sheet before condensing, or grouping, them in the form of a chain. A lease is formed by dividing this sheet of yarn, while it is spread out widely and evenly, into a certain number of equal parts by means of bands of twine, so that although the ends are afterwards condensed into a loose rope and passed through a converting process, the yarn may be opened by means of the bands and laid in a sheet with the ends approximately in the same position, with relation to one another, as they were during the earlier part of the warping process. The yarn can then be placed on the loom beam or section beam or quilled without any excessive entanglement of yarn

or waste of material or labor. Leases must be taken both in the long- and the short-chain systems and whether the yarn is intended for warp or filling. The insertion of the lease band is known as *throwing in a lease*, or *taking a lease*. Leases are always taken at each end of a complete chain and, in the case of a long chain, at intervals throughout its length; that is, if a chain is to be made [illegible] yards in length, a lease will be taken at every [illegible] or [illegible] yards as a precautionary measure in case of an accident of any kind happening to the warp during its passage through the converting or beaming process, resulting in the breakage or entanglement of the yarn. This damage, if slight, will only be a disadvantage until the next lease was reached, as the lease will enable the operator to disentangle the warp and make a fresh start with the ends in their proper position. If the damage is great, the warp must be cut where it occurs and a fresh start made at the next lease band.

7. Thread Lease.—Leases are of two kinds—the *thread* [illegible]

were in the top of the first shed in the bottom of this shed and vice versa. Another band is passed through this second opening and the ends of the two lease bands tied, thus providing a means of maintaining the lease throughout the succeeding processes to which the warp may be subjected. In taking a thread lease, the warp is separated into two equal portions.

8. **Pin Lease.**—A pin lease differs from a thread lease in being composed of larger groups; the warp instead of being separated at every alternate end is separated into alternate groups of 2, 3, 4, or any desired small number of ends. Pin leases are commonly taken in groups of 4; in this case the ends in the warp are separated so as to form a shed with the first 4 ends down, the next 4 ends up, the third group of 4 ends down, and the fourth group of 4 ends up, and so on, and a lease band passed through this shed. Another shed is then formed by reversing the positions of the ends, after which another band is passed through this shed and the ends of the two bands tied. A pin lease is sometimes called a *half-beer lease*, or *beamer's lease*. One of the chief uses of a pin lease is to form a coarse division of the ends to facilitate their separation at the beaming process, since it is easier to separate the warp in groups of 4 ends or in larger numbers than to separate each individual end. The warp is first passed through a coarse comb or reed according to the divisions of the pin lease, and then through a finer comb according to the division, of the thread lease. The pin lease also gives facilities for splitting the warp into sections after dyeing or bleaching, in order to make up the assortment of threads forming various patterns in the warp. For instance, with a pin lease of 4 ends and a warp to be woven in groups of 4, 8, 12, 16, or more ends of one color, it is an easy matter to select the number of ends required. A 25-end pin lease is common for colored warps, in order that they may be split into multiples of 25 ends after dyeing, since as the dyed chain is necessarily all one color, frequently portions of several

chains of different colors are used, to make one warp consisting of several different colors.

A pin lease when taken is generally inserted within 1 or 2 yards of the bands that indicate the thread lease. Thread leases are almost always taken at both ends of a warp, pin leases generally only at one end.

9. Other forms of leases are sometimes taken, one of which is spoken of as an **open lease**, where two consecutive thread leases are taken, one the reverse of the other, thus leaving the warp open between them. **Bunch-knot leases** are formed at the ends of each warp by taking a hand lease dividing the warp into five or six approximately equal sections and tying the ends of the sections together where the warp is cut off. The **bout** is a form of lease made by dividing the ends in the chain by hand into groups equivalent in size to several of the groups formed by a pin lease; these are kept separate by a lease band in the usual way. Chains are sometimes ordered *split in the middle*. This is simply a large bout, the chain being divided into two equal parts and kept separate by lease bands.

The open lease and the bouts are seldom used, the most common forms of leasing being the thread lease, the pin lease, and the bunch-knot lease. Where all three of these appear together in a warp, the one nearest the end of the chain is the bunch knot, the second from the end is the thread lease, and the third the pin lease, but this is not an arbitrary arrangement, since various combinations of leases are made to suit the requirements of customers. The number of leases, the number of ends forming the pin lease, and the positions of the leases in the chain are specified by the users of chain warps, any reasonable combination of leases that may be desired being inserted.

10. **Bands.**—The cord, or band, used for taking and maintaining the lease is made of a number of ends of yarn, usually 16-ply, which are not twisted but simply wound together. It is a good plan for each mill to have its own special lease bands; that is, always to use a band with a

definite number of ends or of special construction so that in case of dispute the warps of that mill can be identified from those of other mills, even after having passed through converting processes.

Water bands are also placed around chain warps when called for. These are merely loops of yarn tied around all the ends of the warp to prevent entanglement in boiling the warp preparatory to the converting process.

CONSTRUCTION OF CHAIN WARPERS

METHODS OF CHAIN WARPING

11. Chains may be made by five methods: (1) *hand warping*, by means of the creel and woof, which is the oldest

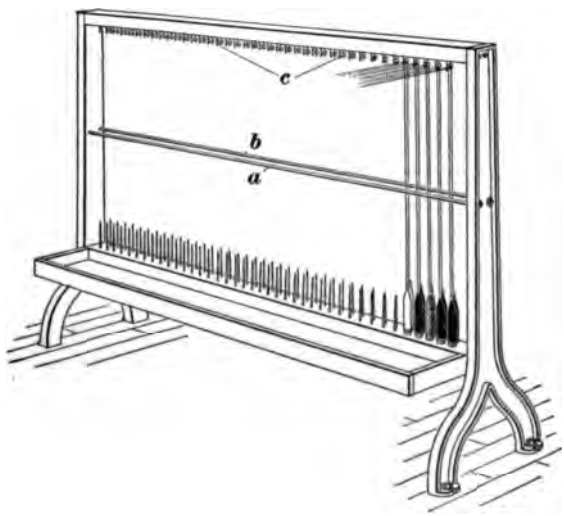


FIG. 3

method, and was formerly used to a large extent in connection with hand-loom weaving but is now seldom seen; (2) *warping mills*, sometimes called upright warpers, circular warpers, or warping reels, an old style of warping rapidly

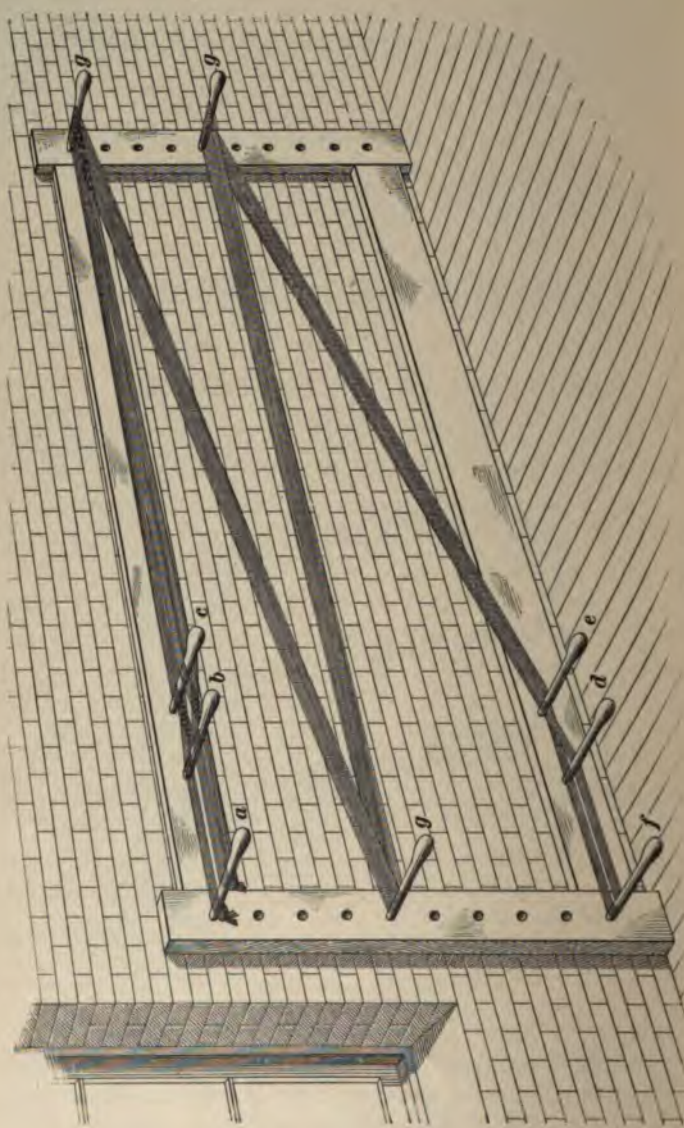


Fig. 4

passing into disuse and only used for short chains of warp yarn, which may be afterwards made into balls or linked warps either by hand or machine; (3) *balling warpers*, which are common beam warpers with the balling attachment and are especially adapted to the making of long-chain warps with less than 800 ends, particularly long chains of filling yarn intended for quilling; (4) *Denn warpers*, which are adapted for making long or short chains (of a small or a large number of ends) that may be put up either in balled or linked form by attachments on the warper itself; (5) *Walcott warpers*, which are used, to some extent, for making short chains with 1,200 ends, or less, that are delivered into a bag or other receptacle without being either balled or linked, but can afterwards be put up in either form by hand or machine.

HAND WARPING

12. Creel.—The method of hand warping requires the use of two wooden or iron frames, one called the *creel* and the other the *woof*. The creel consists of a framework supported on feet, as shown in Fig. 3, the lower beam being arranged to carry two rows of skewers, from 40 to 80 in a row, that are supported in holes drilled in the beam; on these skewers, cops or bobbins of yarn are placed. The upper beam contains the same number of guide wires *c* as there are skewers in the lower beam; the yarn passes through these wires on its way to the woof. Between the upper and lower beams are two guide bars *a*, *b*; the ends from the front row of bobbins or cops pass behind the bar *a*, while the ends from the back row pass behind the bar *b*. After being passed through the guides, the ends are gathered together, loosely, by hand, thus forming a continuous strand of as many ends as there are cops or bobbins on the skewers in the creel.

13. The **woof** is a rectangular framework, usually secured to a wall, consisting of two vertical and two horizontal rails, as shown in Fig. 4. Each vertical rail contains from ten to twenty holes to receive pegs. The vertical rails must be

exactly alike as to the number and spacing of the holes, with opposite holes the same distance apart, usually 10 feet, in every case. In each horizontal rail, holes for two additional pegs are also provided. The creel is movable and is placed a few feet from the woof and at an angle with it.

14. Method of Making Warps.—In making a warp, the warper tender first ties the ends together and slips them over the peg *a*; he then selects the ends from the creel in their proper order, but first makes a lease by passing the first end over the thumb and under the forefinger of the right hand, the next end under the thumb and over the forefinger, etc., in this manner separating the even-numbered from the odd-numbered ends. After the lease is made, it is passed over pegs *b*, *c* in the same manner that it was passed around the thumb and forefinger; as these pegs serve to hold the lease of the warp, they are termed *lease pegs*. All the yarn is then passed around the pegs *g*, until it comes to the pegs *d*, *e*; here it passes under the peg *e*, over the peg *d*, then around *f*, back under the peg *d*, and over the peg *e*. By this means another lease is formed, of sections containing a greater number of threads than in the case of the pegs *b*, *c*, which separated the yarn thread by thread. From the peg *e*, the yarn passes back around the pegs *g* in reverse order until it reaches the pegs *b*, *c*, where a lease is again formed and the ends then knotted around *a* and cut.

The manner in which the warp yarn is wound around the pegs places twice as many ends on the woof as are taken from the creel each time that the yarn is passed back and forth, since it commences and ends at the same point. The length of the warp is governed by the number of pegs that are used; for instance, if there was the usual distance of 10 feet between the vertical rails of the woof and the warp was required to have 480 ends and be 100 yards long, it would be passed across the frame thirty times (30×10 feet $= 300$ feet $= 100$ yards), necessitating the use of thirty-one pegs in the vertical rails. If 120 ends were taken from the creel for this warp, four layers would have to be placed on

the woof; that is, the yarn would be passed from *a* to *f* and back to *a*, where it would be tied and cut and the operation then repeated once. This system of hand warping is now entirely out of date, except for making warps for hand looms or small pattern warps in designing rooms or textile schools.

WARPING MILLS

15. A warping mill, Fig. 5, consists mainly of a large circular reel made either 10, 12, 14, 16, 18, 20, 22, or 25 yards in circumference, a heck, and a curved creel. The term *mill* is frequently applied to the reel alone, as this is the main part of the warper. It is constructed around a vertical shaft *a* that is supported in a footstep secured to the floor, and revolves in a bearing a_1 attached by braces to the ceiling of the room or other suitable support. Around the circumference of the mill vertical rods a_2, a_3, a_4 are secured. The rods a_3, a_4 are shown carrying cross-pieces, or clamps, b, b_1 in each of which are inserted two pegs b_2, to which the ends of the chain can be secured. The vertical rods are supported from the central shaft by a stayed rigid framework, so that the reel may revolve truly, the bottom of the rods clearing the floor sufficiently to allow the driving belt to pass underneath the mill.

The mill may be driven by hand or power. The driving head *c* consists of a short, upright shaft c_1 on which is a flanged belt pulley c_2 that carries a belt c_3 that also passes around another flanged pulley a_5 at the lower end of the central shaft *a* of the reel. By turning the handle c_4 that is attached to the shaft c_1, the reel may be driven in either direction by hand. The arrangement for driving by power consists of a horizontal shaft c_5 that carries two clutch pulleys c_6, c_7, which receive motion from the driving shafting of the room. These pulleys revolve loosely on the shaft and in opposite directions. Between them is a clutch arrangement operated by the handle c_8, by which either pulley may be caused to drive the shaft c_5. Thus the shaft may be driven in either direction, according to which pulley is used for driving it, or

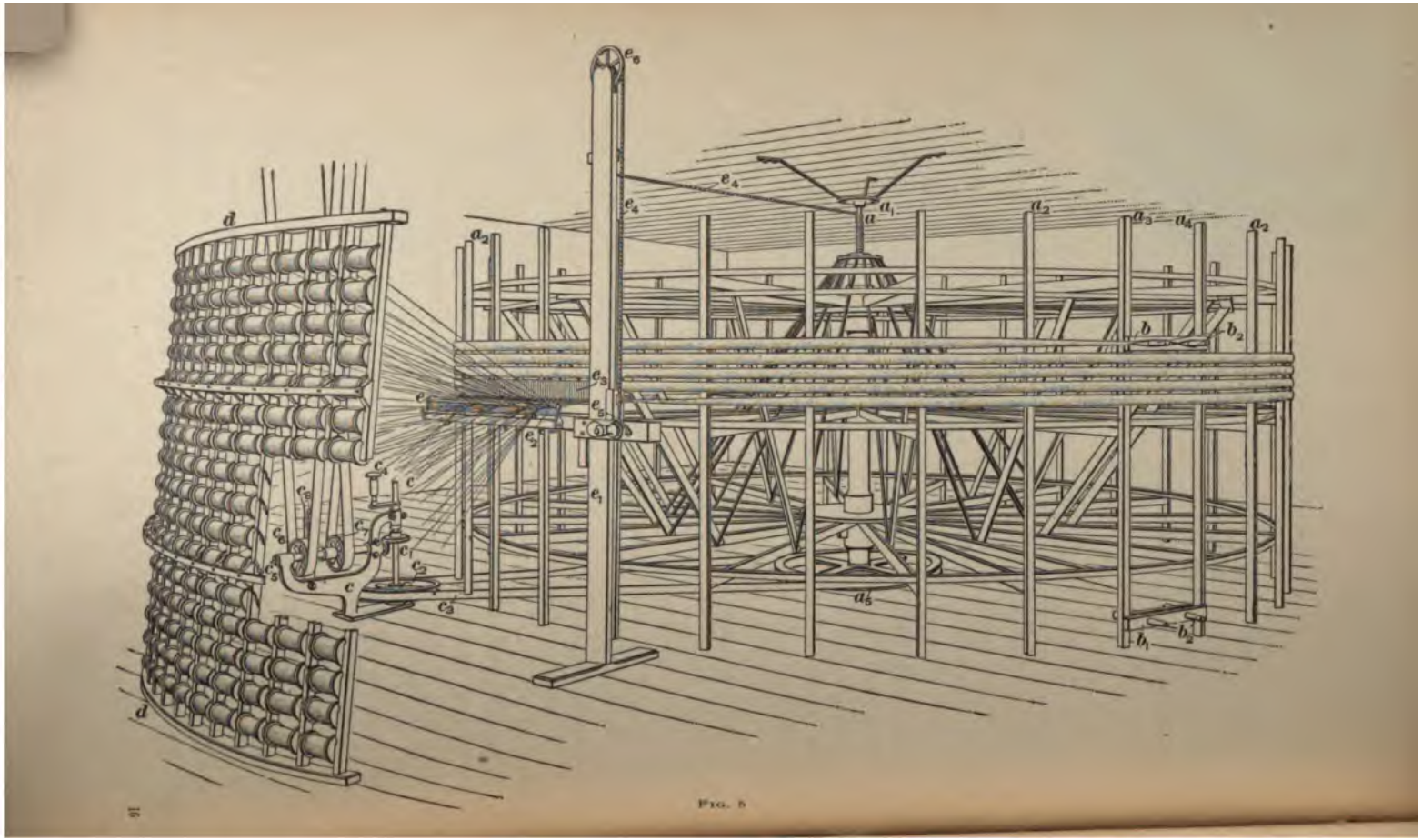

d
d
a_2
a_2
a_1
a_2
a_3
a_4
a_2
e_6
e_4
e_4
e_3
e_5
e_2
e_1
b
b_2
b_1
b_2'
a_5'
c_3'
c_2
c_1
c
c_4
c_5
c_6
c_7
c_8
c_9
c_{10}

Fig. 5

the shaft may remain stationary and the pulleys revolve loosely, the position of the handle c_6 controlling whatever motion is desired. As the shaft c_6 is connected with the vertical shaft c_1 by means of two bevel gears, the mill may be driven in either direction.

16. The creel d is curved and consists of vertical standards slotted to receive the ends of skewers passing through the spools of yarn. The standards are maintained the required distance from each other by horizontal bars, while the whole framework is attached to the floor and also, by suitable braces, not shown in Fig. 5, to the ceiling of the room.

17. The ends of yarn from the spools pass to the circular reel through the heck e, which is supported by a heck post e_1 up and down which it slides. The heck consists of a framework e_2 with guide rods, between which the yarn passes to a number of porcelain tubes e_3, known as pot eyes, that are mounted on vertical rods, on which they can rotate. The yarn passes between the pot eyes in groups of the required number of ends for a pin lease. Each end is then conducted through one of a number of wire eyes, not shown in the figure but situated between the pot eyes and the reel; one half of these wire eyes are mounted on one frame, and the other half on another, which arrangement, since either frame may be raised, facilitates the taking of a thread lease; when the lease is not being taken, all the wire eyes are level. From these the yarn passes to the reel, being condensed into a loose rope to form the chain by passing through a trumpet-shaped guide. The heck is raised and lowered on the heck post by means of a rope e_4, one end of which is attached to the heck at e_5. The rope passes upwards around the pulley e_6, then downwards for a short distance and around a small pulley, and thence to the shaft a, to which the other end is attached. As the mill revolves in one direction, this cord winds around the upper part of the shaft, consequently drawing the heck up the post; when the mill revolves in the other direction, the cord is unwound, which allows the heck to fall.

18. Method of Making Warps.—The upper clamp b and lower clamp b_1 are movable and can be secured to any two of the vertical rods, as required. At the commencement of a warp, the upper clamp b is placed near the top of two of the vertical rods, in case a warp that will occupy the whole of the surface of the mill is required; but if a shorter warp is to be made, the clamp is lowered as far as is desired. The mill is then revolved until the heck is wound to the height of this clamp, after which the ends, which have previously been passed through the pot eyes and wire eyes of the heck, are knotted together and passed around the pegs in this clamp. The mill is then revolved slightly, by turning the handle c_4, until motion has become sufficiently accelerated, when the handle c_5 is moved so as to throw in the clutch, which drives the mill by power in the required direction. As the mill revolves, the chain of warp is wound around it in a spiral manner, because the revolution of the central shaft a uncoils the rope c_4, which gradually lowers the heck.

The motion of the mill continues until as many layers of chain have been wound around it as are necessary to form the total length of warp desired, when the handle c_5 is moved to such a position as prevents any motion being imparted to the mill. The lower clamp b_1 is then secured to two of the vertical rods at the lower end of the chain and the ends of the warp passed around the pegs. After the lower end of the warp is secured, the operator again turns the mill slowly by hand and then throws the handle c_5 in the opposite direction, so as to cause the mill to be revolved by power in the opposite direction to that in which it was moving. This places another layer of yarn on the previous one, because the heck this time is moved upwards by means of the rope c_4 being coiled on the shaft a. The mill continues to revolve until the point in the upper part where the chain was commenced is reached, when the ends of the warp yarn are again secured to the pegs in the clamp b. This completes one *journey* of the mill, sometimes called one *gang*, or *bout*.

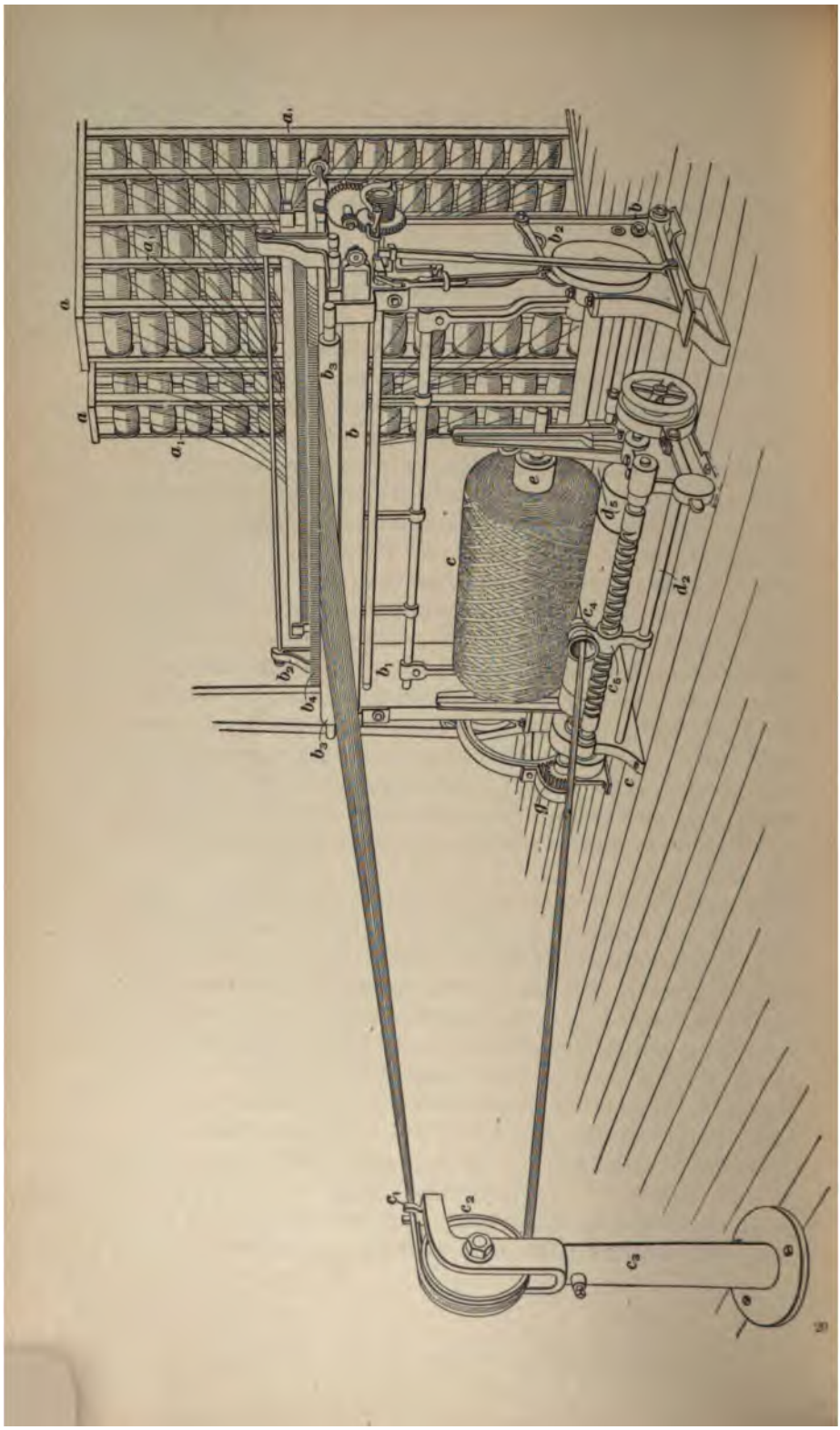
Up to this point, the warp has been made of the required length, but only contains twice as many ends as there are

bobbins in the creel. These are so arranged that this number will be a factor of the total number of ends required in the warp. For instance, if 1,680 ends are required and there are 280 ends in the creel, the heck must move down three times and up three times, making three journeys.

19. Leases are taken on the circular warper at the heck. The thread lease is taken by means of the two frames carrying the wire eyes; the odd-numbered ends pass through the eyes in one frame and the even-numbered through the eyes in the other frame. By raising each frame alternately two sheds are formed and kept apart by the first finger and thumb of the operator until the lease reaches the reel, when he removes them from his finger and thumb and passes them over the pegs b_1 of the clamp b so that the ends occupy the same relation to each other as when on the first finger and thumb; that is, the odd-numbered ends pass over one of the pegs b_1 and under the other, while the even-numbered ends pass under and over in the reverse manner to the odd-numbered ends. The pin lease is taken by what is known as *picking the lease;* that is, the groups of ends that are separated by the pot eyes are taken alternately first under the thumb and over the first finger and then over the thumb and under the first finger, in which order they are placed on the two pegs b_2.

The length of warp is, of course, determined by the number of revolutions made by the mill. If a warp 400 yards long is to be made on a 16-yard mill, twenty-five revolutions will be given to the mill in each direction. When as many layers as are necessary to give the required number of ends have been wound on the mill, it is stopped and the final lease taken, the ends of the yarn connecting the warp with the heck cut and tied, and the chain removed by hand, the operator usually winding it around his wrist in a ball form.

Circular warping mills are not now used to any great extent, the objections to the system being its crudeness, the large amount of floor space occupied, and the small production, as compared with more modern systems of warping.


a
a1
a2
a3
b
b1
b2
b3
b4
b5
c
c1
c2
c3
c4
c5
d
d1
d2
d3
d4
d5
e

There is also a defect in all warps made on this principle, especially those of any bulk, owing to the fact that the outer layers of yarn are longer than the inner layers, which causes the ends that were warped last to be slacker in the warp in the loom than those wound on first.

BALLING WARPERS

CREEL AND WARPER FRAME

20. The ordinary section-beam warper used in the regular cotton-warp-preparation system for making section beams is so constructed that it can also be used in connection with a balling attachment placed in front of it for making ball warps. When a balling warper is intended only for making balls it is constructed in many respects like the common section-beam warper, but without those parts of the mechanism necessary in making a beam. A **balling warper** suitable for making balls only is shown in Fig. 6, and consists of the creel a, the warper proper, or warper frame, b, and the balling attachment c.

21. Passage of the Yarn.—The yarn passes from the creel a through the various parts of the warper proper b, including the reed b_4, over the front roll b_5 to the guide fork c_1 and around the return wheel c_2. It then passes through the trumpet c_4 and is wound on the wooden core e.

22. The **creel** a is what is known as a **V**-shaped creel, since it consists of two sides similar in construction that rest on the floor in the shape of a **V**, connected at the end nearest the warper and separated at the rear end by a distance of about 5 feet. A number of vertical standards a_1 are connected at the top and bottom to crosspieces, by which they are held a sufficient distance apart to allow a spool to be placed between each pair of vertical standards. Attached to the insides of the standards are a sufficient number of iron bearings for the spools required; sometimes instead of iron steps, recesses are cut in the wooden framework and

porcelain or glass steps inserted. The steps are placed in horizontal rows and hold the iron or wooden skewers on which the spools are mounted. The **V** shape of the creel permits those ends from the rear vertical rows to pass to the warper without coming in contact with the ends from those vertical rows near the front.

23. The **warper frame** consists of two upright standards b_1, b_2 that are rigidly attached by means of rods and support rolls, guide rods, reeds, etc., which maintain the yarn in an even horizontal sheet until it reaches the front roll b_3. The guide fork c_1 that serves to condense the yarn into a chain and the return wheel c_2 are supported by a stand c_3 attached to the floor. The return wheel c_2 revolves freely and serves merely as a guide for the chain in its passage to the balling attachment.

24. Leasing.—The kind of lease usually taken at this style warper is the thread lease, for which it is customary to use a reed, as shown at b_4, Fig. 6. The reed for the machine under consideration consists of a foundation supporting a number of steel wires, in about the center of each of which is an eye. The yarn is threaded through the drop wires of the stop-motion mechanism and then through the reed, alternate ends passing through eyes in the steel wires, while the other ends pass through the *dents;* that is, between the wires. When the machine is running, the ends emerge in an even sheet and are then gradually condensed to form the chain. When it is necessary to take a lease, the reed is alternately raised and lowered by suitable mechanism. Raising the reed also raises the ends that pass through the eyes, while lowering the reed depresses these ends; on the other hand, the ends that pass through the dents remain in their normal position during the whole time.

For some makes of balling warpers, instead of using perforated steel wires a leaded reed is used. This consists of stiff, steel wires so connected as to stand upright on a firm foundation, the lower half of each alternate dent being filled with lead. Each end in the warp passes through a dent, so

that only alternate ends pass through the leaded dents. When it is desired to take a lease the reed is raised, which

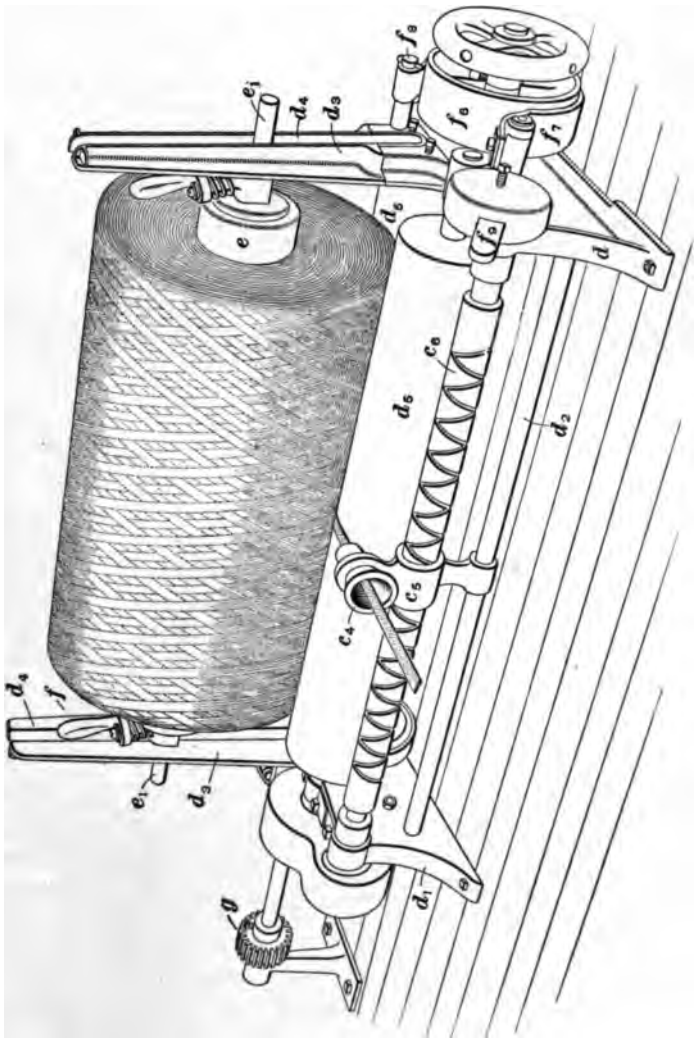
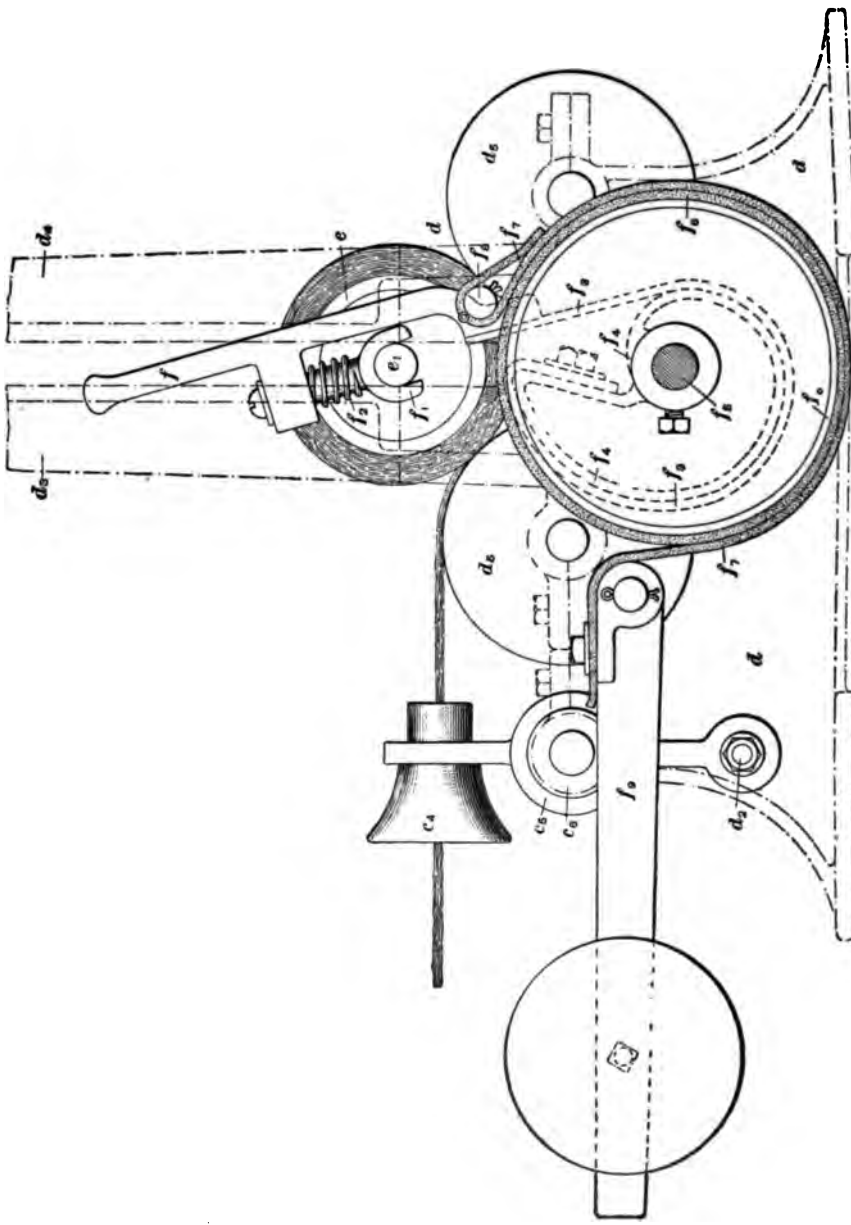


FIG. 7

lifts those ends in the leaded dent, while those in the other dents remain down, thus enabling twine to be passed between alternate ends so as to produce a lease.


d_8
e
d
d_5
f_{10}
f_{11}
f_9
f_8
f_3
f_6
f_4
f_5
f_1
e_1
f_2
d_6
f_7
d
f_0
d_2
c_3
c_5
c_6

CONSTRUCTION OF BALLING ATTACHMENT

25. A larger view of the balling attachment alone is shown in Fig. 7, while Fig. 8 is an end elevation with the hand wheel removed and the framework shown in dot-and-dash lines so that the various working parts can be more clearly seen. The attachment consists of two upright supports d, d_1 that form the sides and are connected by cross-bars secured to each side, one of which is shown at d_2. The upper portion of each support terminates in two upright arms d_3, d_4 that serve as guides for the shaft e_1 during the formation of the ball. For convenience in doffing, etc., the upper parts of these arms are made removable. Mounted in bearings on the supports d, d_1 are two rolls d_5 about $5\frac{3}{4}$ inches in diameter, which are connected by gearing so as to revolve at the same circumferential speed. The ball rests on these two rolls and is wound around a wooden core e, through which is a square hole for the shaft e_1; the latter is squared at its central part, but has circular ends that rest between the two pairs of vertical guides. Sometimes the shaft e_1 is replaced by an expanding mandrel, in which case a paper tube is passed over it and the mandrel expanded, in order to cause the tube to be gripped and be driven by the rolls on which it rests.

26. Driving.—The machine is driven in the usual manner for warpers of this or the beam type; that is, it has the tight-and-loose and slow-motion pulleys. On the same shaft with the pulleys is a small spur gear driving the gear g, Figs. 6 and 7, through a large carrier gear. The gear g is situated on the shaft of one of the rolls. Another gear on this roll shaft drives, by means of carrier gears, a gear on the end of the other roll shaft and a gear on the end of the traverse worm-shaft c_4; both rolls d_5 revolve in the same direction. As the core e rests on the rolls d_5, it is revolved at the same surface speed as these rolls; and as they are positively driven, the yarn is drawn off the spools in the creel, through the warper, and wound around the core.

27. Traverse Motion.—In order to produce the cylindrical form of ball desired, it is necessary to give a traverse motion to the trumpet c_4, and consequently to the chain passing through it, which when only one ball is formed at a time is generally almost equal to the width of the core—the trumpet is moved almost to one end of the core, is then reversed and moved almost to the other end, and again reversed, with a movement comparatively slow and even, so as to build up the chain on the core in successive layers of spiral coils.

The traverse motion is obtained by means of a heavy steel screw c_6 mounted in bearings in the end pieces of the baller. The shaft has a continuous double thread cut deeply into its surface, one thread right-hand and the other left-hand, connected at each end. Around the threaded portion is passed a bracket c_5, which carries a pin that projects into the thread.

The lower end of the bracket is enlarged to fit over the rod d_2, which serves to hold it in an upright position and steady it; as it carries the trumpet c_4 at its upper end, the rotary movement of the screw shaft will produce a horizontal reciprocating movement of the trumpet, thus giving the desired traverse to the chain. The speed of the screw shaft is so regulated as to give an open spiral wind of the chain on the core.

28. Winding Mechanism.—At each side of the baller is a casting f, Fig. 8, that has a handle at its upper end and carries a lug, through which passes the shank of a fork f_1 that rests on the shaft c_1. On the shank of this fork, between its arms and the lug of the casting f, is a spring f_2, that has a tendency to force the forked portion as far from the lug as is allowed by the washer secured to the upper end of the shank of the fork. At the lower end of the casting f is attached a leather strap f_3, which passes down and around a scroll-shaped casting f_4, shown in dotted lines, mounted on the shaft f_5. Securely attached to this shaft is a friction pulley f_6 (Figs. 7 and 8), partly around which passes a

friction strap f_7 that is secured at one end to a stud f_8 on the stand d and at the other end to a weighted lever f_9.

This friction mechanism is necessary in order to keep the core pressed on the driving rolls d_8 with sufficient pressure to wind the chain on its surface. When a ball is first started, the shaft e_1 of the core is in its lowest position and the casting f also being in its lowest position allows the scroll f_4 to assume a position practically as shown in Fig. 8 and almost the whole length of the strap f_3 to be wound around it. When the scroll f_4 is in the position shown, the strap f_3 acts on the small diameter of the scroll, and hence a greater pressure is exerted on the core because a greater force is required to turn the friction pulley f_6 under these conditions. As the ball increases in size, the ends of the shaft e_1 rise between the vertical guides d_3, d_4, thus raising the casting f and causing the scroll f_4, shaft f_5, and friction pulley f_6 to revolve so that the strap f_3 will be gradually unwound from the surface of the scroll. As the strap f_3 is unwound from the surface of the scroll in consequence of the increasing diameter of the ball raising the casting f, the effective diameter of the scroll increases so that the leverage of the strap f_3 is increased and less force is required to raise the core. The decrease in the amount of power, or pressure, required to overcome the friction is necessary in order that an even tension may be obtained; for as the ball increases in size, it also increases in weight, thus counterbalancing the decrease in the amount of power required to overcome the friction, so that the tension for winding the yarn will be practically the same throughout the building of the ball. An even tension is required to make a perfectly formed ball. If the tension at the beginning were less than at the finish, the ends of the ball would bulge out and be ragged. If the tension were less at the finish than at the beginning, a soft ball would be formed. If a circular disk were used in place of the scroll, the leverage would be the same all the time; consequently, the same amount of tension would be caused by the friction mechanism throughout the building of the ball, and as the

ball increased in size and weight, the amount of tension would be increased, due to the increased weight of the ball.

29. Measuring Motion.—On most ball warpers, an arrangement is provided to register the number of yards of chain passing through the machine by means of a finger, or fingers, moving around the face of a graduated dial, the arrangement being called a *clock*, sometimes a *lease clock*. Combined with the measuring arrangement, there is usually an arrangement by which the warper is stopped automatically when certain lengths have been warped, a bell also being rung to notify the operator. The measurements required to be recorded are the terminations of cuts, the points where it is desired to insert leases, and the termination of the complete chain. The cut lengths are generally short, usually about 50 yards; the leases are inserted at regular intervals, usually every 500 or 1,000 yards; while the complete chain varies from 1,000 to 10,000 yards, or more.

Elevations of a mechanically operated lease clock are shown in Fig. 9 (*a*) and (*b*). The clock is driven from the shaft of a measuring roll, which carries a single worm h that drives a worm-gear h_1 of 48 teeth. The yarn passes over this measuring roll in its passage through the warper proper. On the same stud with h_1 is the gear h_2 of 16 teeth, which drives the *cut change gear* h_4 by means of the carrier gear h_3. The change gear is held on its stud by means of a nut, as shown, and is in a convenient place for removal and replacement with another gear, thus affording a ready means of altering the length of the cuts. On the same shaft with h_4 is a gear h_5 of 16 teeth driving a gear h_6 of 64 teeth, on the same stud with which is a gear h_7 of 16 teeth driving the *lease change gear* h_8. Different sizes of gears at h_8 give different lengths between the leases, in the case of long chains; or different lengths of complete chains, in the case of short chains. On a short supporting shaft j is mounted a curved arm j_1 with its upper end resting against a collar j_2 that is on the same sleeve as, and revolves with, the cut change gear h_4. In this collar is cut a notch sufficiently large to allow the

point of the curved arm j_1 to drop into it when the collar has revolved until it is in a suitable position. As this arm drops into the notch, it causes a hammer j_3 to strike the

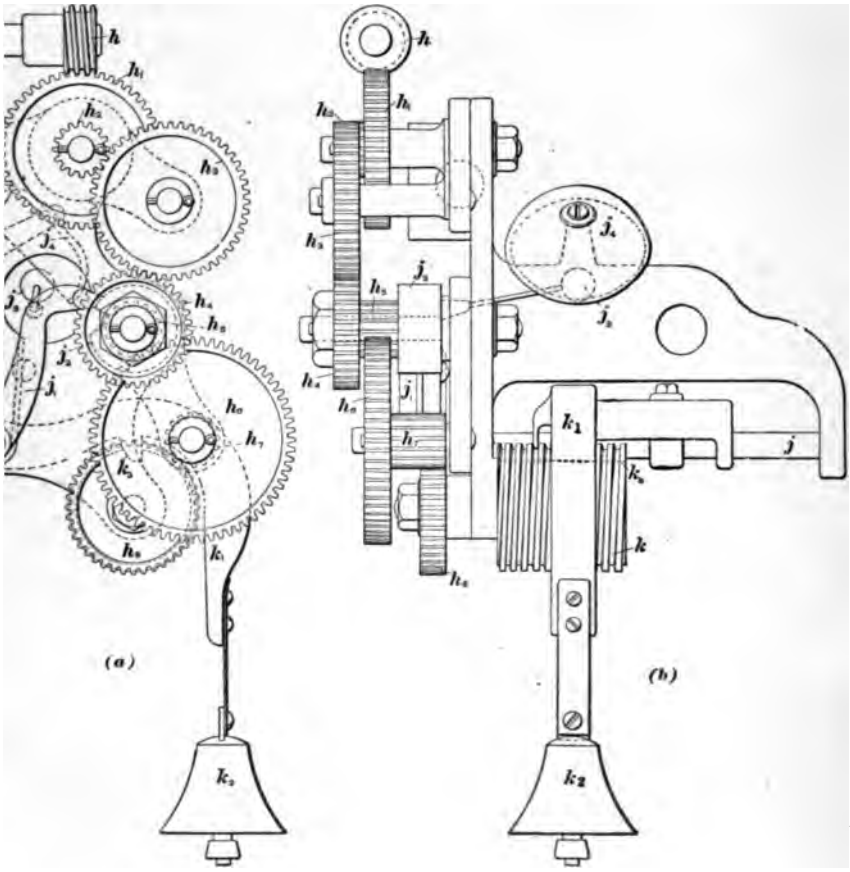


FIG. 9

small gong j_4, thus indicating to the operator that a cut has passed the measuring roll.

On the stud that carries the lease change gear is a barrel k carrying coarse spiral threads, between which rests the curved finger of a casting k_1, which is also supported on the shaft j, on which it can slide. This barrel has a groove k_2

cut lengthwise along its surface, which is wide and deep enough to allow the finger of the casting k_1 to drop into it. When the warper is started, the finger is just beyond this groove. The number of teeth in the train of gears is such as will cause the barrel to make one revolution while the number of yards required between lease bands is passing through the machine, so that when it is necessary to insert a lease, the barrel will have revolved until it is in the right position for the finger of the casting k_1 to drop into the groove, when the vibration of the bell k_2 will cause it to ring. Therefore when the gong rings, the operator knows that a cut has been completed; and when the bell rings, that a lease has been completed, or, in the case of short chains, a complete chain finished.

The thread around the barrel k is such as to provide a number of grooves, usually ten altogether; at each revolution the curved arm k_1 is moved a slight distance outwards, so that ultimately, when the barrel has made the required number of revolutions, the finger of the curved arm escapes altogether from the barrel and falls from it for some distance. The belt is then shipped from the tight to the loose pulley by means of suitable mechanism and the warper stopped, thus indicating the completion of a chain. For example. if six leases are required in a complete warp, at the start the finger is placed in such a groove of the barrel that six revolutions will free it and cause the warper to stop.

30. Calculations for Measuring Motion.—To find the number of yards in a cut when the circumference of the measuring roll and the number of teeth in the gears operating the cut-indicator gong are known:

Rule.—*Divide the product of the driven gears and the circumference of the measuring roll, in inches, by the product of the driving gears and 36 (the inches in 1 yard).*

EXAMPLE.—Find the number of yards in a cut when the measuring roll is 12 inches in circumference and carries a single worm driving a worm-gear of 48 teeth, with which is compounded a 16-tooth gear driving, through a carrier gear, the cut change gear of 50 teeth.

SOLUTION.— $\frac{48 \times 50 \times 12}{1 \times 16 \times 36} = 50$ yd. per cut. **Ans.**

31. To find the size of the cut change gear required to produce a certain length cut when the circumference of the measuring roll and the number of teeth in the gears operating the cut-indicator gong are known:

Rule I.—*Apply the rule for finding the length of the cut, in yards, substituting the length, in yards, of the cut required in place of the number of teeth in the cut change gear.*

EXAMPLE 1.—Find the size of the cut change gear required to produce a 50-yard cut with the train of gears given in the example in Art. **30.** The measuring roll is 12 inches in circumference.

SOLUTION.— $\frac{48 \times 50 \times 12}{1 \times 16 \times 36}$ = 50-tooth gear. Ans.

Another rule for finding the size of the cut change gear is as follows:

Rule II.—*Divide the number of yards in the cut desired by the constant for the train of gears operating the cut-indicator gong.*

The constant is found by applying the rule in Art. **30,** considering the cut change gear as a 1-tooth gear.

EXAMPLE 2.—Same as example 1.

SOLUTION.— $\frac{48 \times 1 \times 12}{1 \times 16 \times 36}$ = 1, constant for the cut change gear.
$50 \div 1$ = 50-tooth gear. Ans.

From the above calculations it will be seen that the number of teeth in the cut change gear is equal to the number of yards in a cut; thus, a 40-yard cut requires a 40-tooth change gear; a 50-yard cut, a 50-tooth change gear; etc.

32. To find the number of yards between leases when the circumference of the measuring roll and the number of teeth in the gears operating the lease-indicator bell are known, apply the rule in Art. **30.**

EXAMPLE.—Find the number of yards between leases when the measuring roll is 12 inches in circumference and carries a single worm driving a worm-gear of 48 teeth. Compounded with the worm-gear is a 16-tooth gear driving the cut change gear through a carrier gear. On the same stud with the cut change gear is a 16-tooth gear driving

a 64-tooth gear that is compounded with a 16-tooth gear driving the lease change gear. The cut change gear in this case has 50 teeth, while the lease change gear has 80 teeth.

SOLUTION.— $\frac{48 \times 50 \times 64 \times 80 \times 12}{1 \times 16 \times 16 \times 16 \times 36}$ = 1,000 yd. Ans.

33. To find the constant for the lease change gear:

Rule I.—*Apply the rule for finding the number of yards between leases, considering the lease change gear as a 1-tooth gear.*

EXAMPLE 1.—Find the constant for the lease change gear for the train of gears given in the example in Art. **32**, the measuring roll being 12 inches in circumference.

SOLUTION.— $\frac{48 \times 50 \times 64 \times 1 \times 12}{1 \times 16 \times 16 \times 16 \times 36}$ = 12.5, constant for the lease change gear. Ans.

To find the size of the lease change gear required to produce a given length of chain between lease bands:

Rule II.—*Divide the number of yards desired between lease bands by the constant.*

EXAMPLE 2.—Find the size of the lease change gear required to produce 1,000 yards of chain between leases.

SOLUTION.— 1,000 ÷ 12.5 = 80-tooth gear. Ans.

34. To find the number of cuts between leases:

Rule.—*Divide the number of yards between leases by the number of yards in a cut.*

EXAMPLE.—Find the number of 50-yard cuts between lease bands 1,000 yards apart.

SOLUTION.— 1,000 ÷ 50 = 20 cuts between lease bands. Ans

35. The fact that the gearing of the measuring motion is constant with the exception of the lease and cut change gears affords a short method of finding the size of the lease change gear required to produce a given length of chain between lease bands. It will be noted that the constant found in Art. **33** (12.5) is one-fourth the number of yards in a cut, or the number of teeth in the cut change gear (50). The relation of these items is always the same, because the number of teeth in the cut change gear is the only variable

quantity in the calculation, which without this item equals $\frac{1}{4}$. The constant, therefore, may always be found by dividing the number of yards in a cut by 4. As the rule for finding the number of cuts between leases requires that the number of yards between leases shall be divided by the number of yards in a cut, and as the rule for finding the size of the lease change gear requires that the number of yards between leases shall be divided by the constant, which it has been proved is always one-fourth of the number of yards in a cut, the number of cuts between leases must always be one-fourth of the number of teeth in the lease change gear. This gives the following short rule for finding the lease change gear required:

Rule.—*Multiply the number of cuts between lease bands by 4.*

EXAMPLE.—Find the size of the change gear required to produce 1,000 yards of chain between leases, the cuts being 50 yards in length.

SOLUTION.—Applying the rule for finding the number of cuts between leases, $1000 \div 50 = 20$ cuts; $4 \times 20 = 80$-tooth gear. Ans.

36. In the case of short chains, where it is intended to stop the warper and cut off the chain when the barrel *k* has made one revolution, the preceding calculations as to the length between lease marks can be considered as applying to the total length of the chain. In the case of long chains, as the number of leases in the chain is known, no calculation is necessary; the finger is simply placed in such a groove of the barrel *k* that the latter must turn around as many times as there are to be leases in the chain before the finger is allowed to drop from it. For example, if a warp of 4,000 yards is required with 500 yards between leases, the barrel must turn around eight times before the chain will be complete; the finger will therefore be set first in such a groove as will require eight revolutions of the barrel to release it.

By suitable arrangement of the fingers and their connection with the stop-motion, balling warpers can be constructed so that the warper is stopped at the end of a cut and of a lease as well as at the end of the completed chain.

37. In the preceding description, references have been made to the baller as equipped for making one ball. In this case, it is customary to build the baller so as to take cores either 30 or 36 inches long, the length of the balls being slightly less than this. Balls can be made of any width narrower than the maximum size for which the machine is constructed, by changing the traverse screw to one of the required length. When exceptionally narrow balls are required, it is customary to make two or even three at the same time on one core. This is accomplished by using a traverse-guide shaft with either two or three guides, as the case requires, the shaft in each case having a corresponding number of sets of threads, so that each guide is operated by a separate set of threads. Thus, if a 36-inch baller is used and two balls formed at the same time, each ball will be slightly less than 18 inches in length, while in case three balls are made, each ball will be slightly less than 12 inches. The number of ends that can be placed on one ball depends on the creel capacity. The largest creels are made for 810 ends, but this is an unusual size, the creels being usually constructed for 510 spools.

38. A warper similar to that described is usually driven by a 1½-inch belt and requires about ½ horsepower. The warper tenders are usually women or girls, one of whom attends to two or more warpers, depending on her ability, the speed of the machine, the counts and quality of the yarn run, as well as many other important points.

The speed of the warper is such as to deliver from 50 to 60 yards of chain per minute when the belt is on the tight pulley; but the net production is about 25 per cent. less than this, on account of stoppages for replacing spools in the creel, leasing, doffing, cleaning, and repairing broken ends, including the allowance that is necessary for the time during which the belt is on the slow-motion pulley.

No definite information can be given as to the number of ends or the length and weight of the balled chains, since this varies very widely according to requirements of pur——

hasers. Balls may be made as heavy as 300 pounds or more and from this downwards as light as is required. Balls are shipped on the cores on which they are built; each ball is wrapped with burlap lined with paper, the ends of which are then sewed. Ballers provided with expanding mandrels over which paper tubes can be placed are sometimes used in order to avoid the expense of shipping balls on the wooden cores, since the paper tubes are much lighter and save freight as well as the expense of returning empty cores.

VARIATIONS IN CONSTRUCTION

39. The arrangement shown in Fig. 6, with the return wheel at the extreme forward end of the apparatus and the balling attachment beneath the sheet of ends, is one commonly used where it is desired to economize in floor space; about 22 feet by 7 feet is occupied by this arrangement. Other arrangements are possible; for instance, the balling attachment may be placed ahead of the return wheel, the yarn passing in almost a straight line from the warper proper to the balling attachment, instead of returning on itself, as shown in Fig. 6. This renders all parts of the warper and balling attachment more accessible, but occupies about 28 feet by 7 feet of floor space. Neither of these arrangements affords the attendant the greatest possible facility of access to the yarn in the warper, such as is required in order to properly piece up the broken ends and pass them through the eyes of the stop-motion. To provide for this, two other methods of applying the balling attachment to the warper are sometimes used. One is to carry the sheet of ends from the warper to the ceiling of the room, pass it over a roll, and then bring it down to the guide eye of the balling attachment; the sheet of ends is contracted as it passes downwards. The balling attachment is placed in any convenient position so that the yarn by passing over the roll will form an arch, under which the attendant can pass and more easily reach the various parts of the warper. The other arrangement is to construct a platform between the

warper and the balling attachment and pass the sheet of ends downwards and underneath this platform, then upwards and around a guide pulley attached to the ceiling, and then downwards to the guide eye of the balling attachment. In this case, the operator can stand on the platform under which the ends are passing and replace broken ends in the most convenient manner.

Another arrangement, known as the *Clark balling attachment*, is similar in many respects to the one shown in Fig. 6, except that the balling apparatus rests against, and is driven by, the regular cylinder of the beam warper, thus avoiding the necessity of a separately located balling attachment.

CHAIN WARPING

(PART 2)

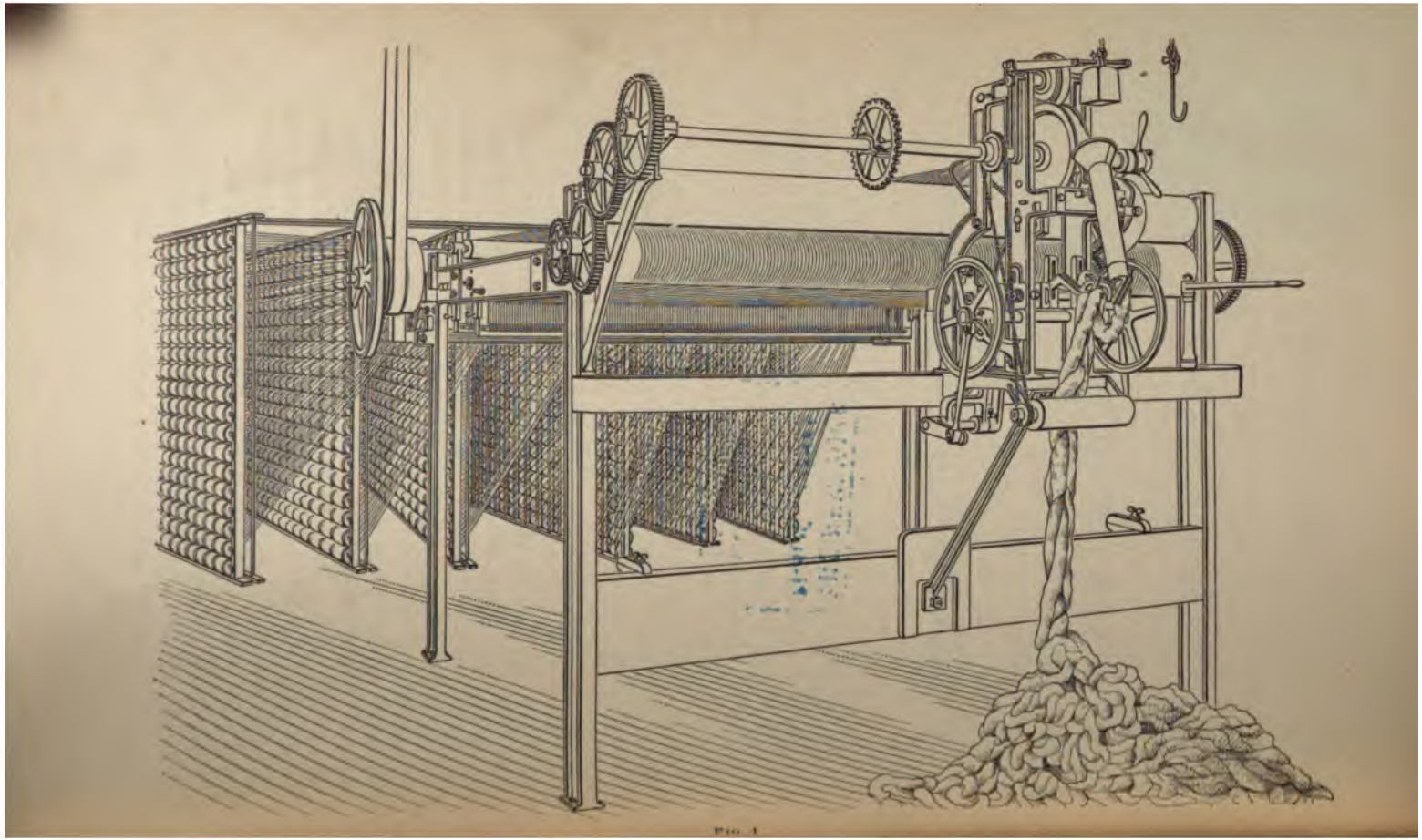
CONSTRUCTION OF CHAIN WARPERS

DENN WARPERS

1. The machine in most common use for making chains is the **Denn warper.** Owing to its adaptability for making either balled or linked chains, with a large number of ends (because of the possibility of using large creels) and of any required length, the advantages of this machine are so evident as to have caused its wide use during recent years. A common type of Denn warper equipped with one linking head is shown in perspective in Fig. 1 and in section in Fig. 2.

2. Passage of Yarn.—The spools of yarn are placed in the creels *a*, Fig. 2, and the ends conducted through an eye board *b*, each end passing through a separate eye, thence under a roll c, and over another roll c_1; each end then passes through a drop wire in the stop-motion *d*, where the mechanical stop-motion is used, after which the ends are all collected in a sheet and passed over the roll c_2. They are next threaded through the harnesses *f*, *g*, which are used only when leases are taken, and then pass around a measuring roll *h*, on which is a presser roll h_1, both of which are of cast iron. The sheet of yarn is returned around a roll *j*, up to which time the yarn has been arranged in a wide sheet. From this point, however, the sheet is contracted by means of an arch *k*, until by the time it reaches the guide fork k_1 it is in the form of a rope of yarn, which then passes to the linking arrangement *l*.

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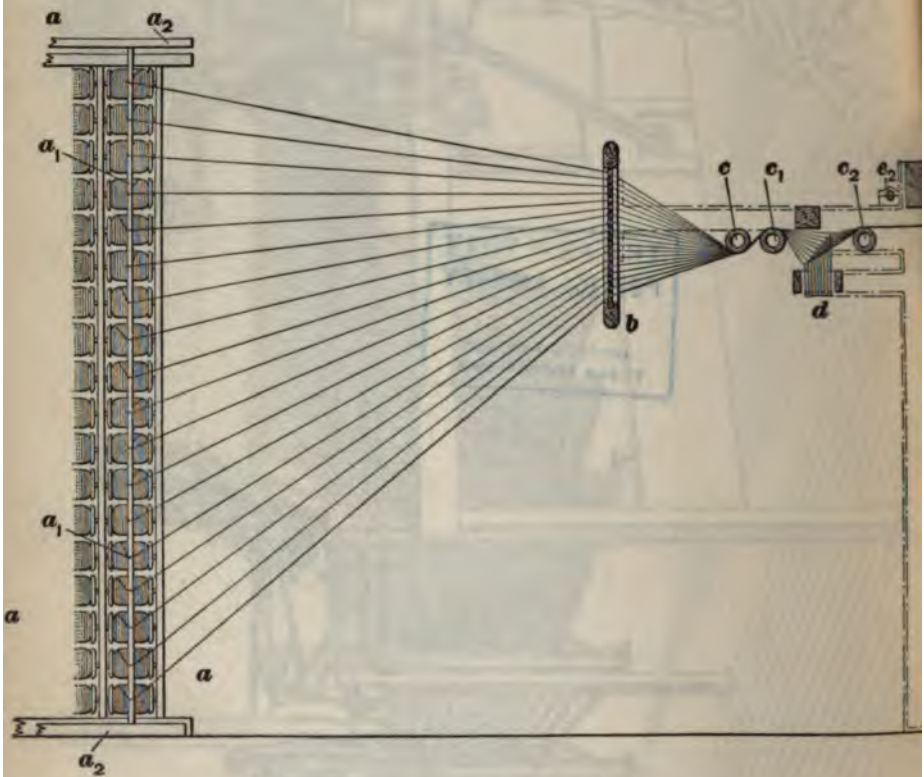


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The machine under description is equipped with the mechanical stop-motion, the common type of measuring motion, and with one linker only, but different arrangements of Denn warpers are in use. For instance, an electrical stop-motion is now generally used instead of a mechanical one, two linkers may be applied instead of one, or the linker may be disconnected and one or more balling attachments applied. The construction of the warper illustrated will be described, as it contains most of the essential parts of any Denn warper, after which variations in the construction of Denn warpers will be referred to.

3. Creels.—A feature of Denn warpers is the large creel capacity, as compared with other warpers. The most common size of machine is that which provides for 2,250 ends, but they are made for 2,430, 2,520, 2,808, 3,006, or 3,204 ends, as required. In order to provide for this large number of ends a number of separate creels are used, generally six, all similar in construction. They are vertical, constructed of wooden standards connected at the top and bottom by a wooden framework, and adjusted at the required distance to allow a spool to be inserted between each pair of standards. Attached to the standards are iron steps, in which the spool skewers rest, carrying the spools. Immediately in front of the face of the creel from which the yarn is delivered, in case a mechanical stop-motion is used, are a series of vertical iron rods a_1, Fig. 2, supported at the top and bottom in a framework a_2, each being placed about opposite the center of each vertical row of spools. This arrangement is better shown in Fig. 3, which is a plan view of the warper and a number of creels, only the ends of the latter being shown, in order to indicate their location. It will be seen that each end of yarn passes from its spool around the vertical guide rod and then at an angle toward the eye board of the warper. In a warper equipped with an electrical stop-motion, the iron rods are not used; a wooden standard carries the electrical connections and the stop-motion wires occupy about the same position as the iron rod.


a
a2
a1
a1
a
a
a2
b
c
c1
c2
d

The size of the creels is determined by the number of ends that it is intended to warp; the creels are generally arranged with spools in vertical rows, there being as many vertical rows and as many separate creels as are necessary to bring up the creel capacity to the total required; for instance, a warper for 2,250 ends has one creel with 20 vertical rows and five creels that each have 21 vertical rows, each row having 18 spools, which gives a total creel capacity of 2,250 ends. One for 2,432 ends has six creels, the two outer ones each having 26 vertical rows of spools and the four inner ones, 25 vertical rows, with 16 spools in each vertical row—in all $(26 + 25 + 25 + 25 + 25 + 26) \times 16 = 2,432$. The creels should be firmly stayed and set such a distance apart as will give a convenient passageway between the creels for access in tying in new spools or connecting broken ends.

4. The **eye board** *b*, shown in Figs. 2 and 3, is a thin wooden board, enclosed in a wooden frame and pierced with holes, in which are fixed porcelain guide eyes. There are as many vertical rows of eyes as there are vertical rows of spools in all the creels, and as many eyes in each vertical row as there are spools in one vertical row in the creel; that is, for 2,250 ends there would be 18 eyes in each vertical row in the eye board and 125 vertical rows. The eye board is stationary and simply serves as a guide to bring the ends of yarn into proper position and hold them in the same relative position to one another as the spools occupy in the creels, thus in the case of a broken end facilitating the finding of the spool from which the end has been broken. As the vertical rows of holes in the eye board are numbered to correspond to the numbering of the vertical rows of spools in the creel, by a glance at the eye board the number of the creel and the number of the vertical row of that creel in which the end is broken can be readily determined. The eye board is sometimes called the *holeyboard.*

5. Driving.—One method of driving the Denn warper is shown in Fig. 3. The shaft e_3 receives the power from the shafting of the room by means of the tight pulley e_1,

close to which is the loose pulley e. At each of the outer ends of this shaft is a hand wheel for the purpose of turning the warper by hand when necessary. At the end of the shaft e_2, opposite the driving pulley, is a bevel gear of 26 teeth that drives another bevel gear of 26 teeth on a long side shaft. On the opposite end of this shaft is a bevel gear of 18 teeth that meshes with a 54-tooth gear on the measuring-roll shaft. At the opposite end of the measuring-roll shaft is a train of gears consisting of a 66-tooth gear h_2 that drives, through two carriers, a 96-tooth gear h_1 on the shaft m_2, which carries the lower grooved calender roll m_1. On this shaft is also a 35-tooth gear r, used for operating the linker, and a 33-tooth sprocket gear m_4, used for operating the balling attachment when the linker is not used.

Another method of driving that is being introduced and, in fact, is taking the place of the side shaft and bevel gears is to connect the shaft e_2 with the measuring roll h by means of two sprocket gears and a chain. The gear on e_2 in this case usually contains 10 teeth, and that on h 30 teeth.

MECHANICAL STOP-MOTION

6. After leaving the eye board and passing under the guide roll c and over the roll c_1, which are smooth iron rolls supported on each side of the frame and constructed so as to revolve easily, the yarn passes through the stop-motion, shown in Figs. 2 and 4, if the **mechanical stop-motion** is used. This consists of a rigid wooden framework d_1, Fig. 4, at the top and bottom of which are brass plates d_2, d_3, respectively, each of which is perforated with twice as many holes as there are places for spools in the creels. Through the holes in these plates are passed bent wire staples, or drop wires, d_4 that have a slight turn at their lower ends, so as to prevent their being raised out of the framework. These staples are of different lengths so as to form several tiers when they are all raised; immediately above the top portion of each tier, when the wires are raised, are two small guide

rods d_4. The object of arranging the stop-motion wires in tiers is to provide for inserting the ends of yarn at several heights, so that a large number of ends may pass through the stop-motion without crowding and so as to give facilities for finding broken ends and replacing them through their proper wires in the stop-motion.

When all the wires are threaded with yarn, their lower ends are level, so that in considering the operation of the

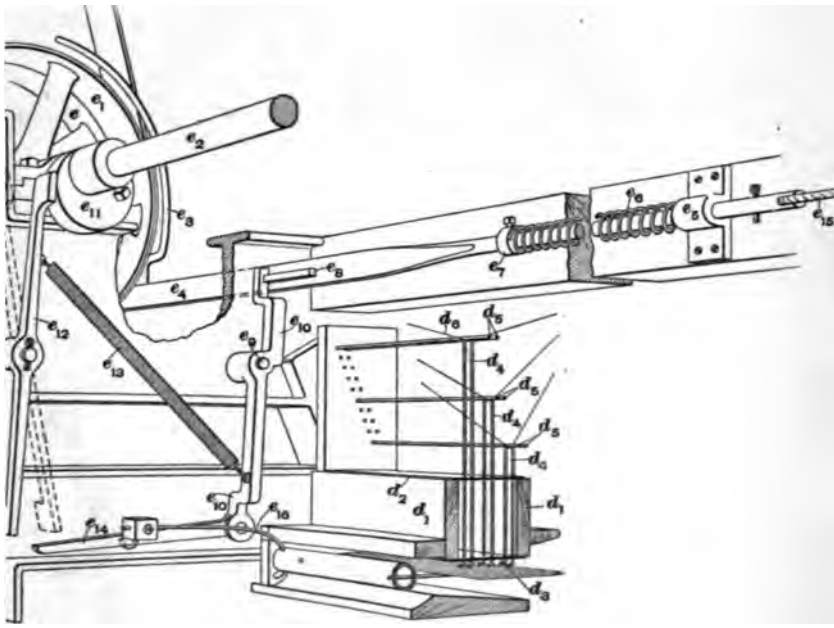


FIG. 4

stop-motion the different heights of the wires may be ignored. After passing the stop-motion, all the ends of yarn are again collected into one wide horizontal sheet over the roll c_3, Fig. 2. In passing between the two rolls c_1, c_2 every end is slightly depressed, in consequence of the position of the stop-motion, and every end passes underneath one pair of guide rods similar to d_4, Fig. 4. Each pair of guide rods is spread sufficiently to allow the upper ends of

the stop-motion wires in the row directly below it to stand between its two rods. Thus, when the ends forming the upper sheet d_6 are in position beneath the guide rods d_8, with each end threaded through a stop-motion wire, there will be one row of stop-motion wires across the machine suspended from this sheet of ends, with the bottom of the wires just projecting through the lower brass plate d_3; similar rows of shorter wires are suspended from other sheets of ends. In Fig. 4, only three of the stop-motion wires are shown, the others being omitted for clearness. The wires shown are for three sheets of ends, as indicated.

7. The belt that drives the tight pulley e_1, Fig. 4, of the warper passes through the guide fork e_2, which is supported on a horizontal rod e_4 that passes through a bracket e_5 attached to the wooden framework of the machine; on this rod is a spring e_6, which is held in position by a collar e_7 setscrewed to the rod. On the flat part of the belt-guide rod is a projection e_8; and below this, suspended from a stud e_9, is a lever e_{10}, to the lower end of which is attached a latch e_{14} supported near its middle by a wire hook. An eccentric e_{11}, fastened on the shaft e_2, gives a constant reciprocating motion to a vertical lever e_{12} suspended on a stud at its center; the upper end of this lever is constantly drawn against the surface of the eccentric by means of a spring e_{13}, which is also connected to e_{10}. The extreme positions of the lever e_{12} are shown by the solid and the dotted lines, the path of its movement at the lower end being immediately over the end of the latch e_{14}, but out of contact with it unless it should be raised.

The driving belt is drawn from the loose pulley e to the tight pulley e_1 by means of a rope e_{15} secured to the belt-guide rod; this rope passes around part of the machine, so that it may be started from the front or from either side near the shaft e_2. The pulling of the rope results in compressing the spring e_6 and drawing the shipper rod a sufficient distance to admit of the upper end of the lever e_{10} falling behind the projection e_8 on the rod e_4, thus holding it and retaining

the belt on the tight pulley until the upper end of the lever e_{13} is moved from the belt-guide rod, when the projection is released and the coil spring throws the belt guide and belt from the tight to the loose pulley.

8. The warper is stopped in the following manner at the breakage of any end passing through the stop-motion. Below the drop wires of the stop-motion is a sheet of brass gauze resting on levers and so accurately balanced that the weight of even one wire falling on it will cause it to depress the arms on which it rests and thus raise the arm e_{15}, Fig. 4, This arm carries the wire hook that supports the latch e_{14}; and consequently, when e_{15} is raised, e_{14} is also raised, so that its outer end comes in the path of the lower end of the lever e_{12}, which at its next inward movement strikes the end of the latch e_{14}, pressing it back and thus forcing the upper end of the lever e_{10} away from the belt-guide rod, with the result that the belt is shifted to the loose pulley and the machine stopped. The attendant, by noting which wire has dropped on the sheet of brass gauze and the corresponding hole in the eye board, can easily trace the spool from which the end has broken. He should then take hold of the broken end on the spool and carry it forwards to the eye board, through which it is threaded in a manner similar to that of threading a needle. From the eye board, the end is passed under the roll c, Fig. 2, over the roll c_1, and is then ready to be passed through the drop wire in which it belongs. Before this can be done it is necessary to raise the drop wire so that a small drawing-in hook can be used to draw the end through it. The tender raises the drop wire, either with one of his fingers or by raising the sheet of brass gauze so that it will occupy its proper position, and then passes the hook through it from the front. The end that has been brought forwards is caught on the hook and drawn through the wire, and then passed over the roll c_2 and pieced to the broken end in the machine. The machine is now started slowly and the speed gradually increased until full speed is attained. The distance from the stop-motion to the measuring roll h and back to the return

roll j gives a number of yards of yarn, and as the machine stops promptly, it is seldom that the broken end has passed beyond the return roll, thus always giving an opportunity to piece it up.

LEASING HARNESSES

9. The leasing harnesses f, g are shown in Fig. 2 and, in detail, in Fig. 5 (a) and (b); f is the harness for taking the thread lease and g the harness for the pin lease. Each consists of a rectangular wooden framework with steel rods f_1, g_1 secured to the upper and lower horizontal bars. On these rods, heddles f_2, g_2 are threaded so as to be retained in a vertical position, but with freedom to move laterally.

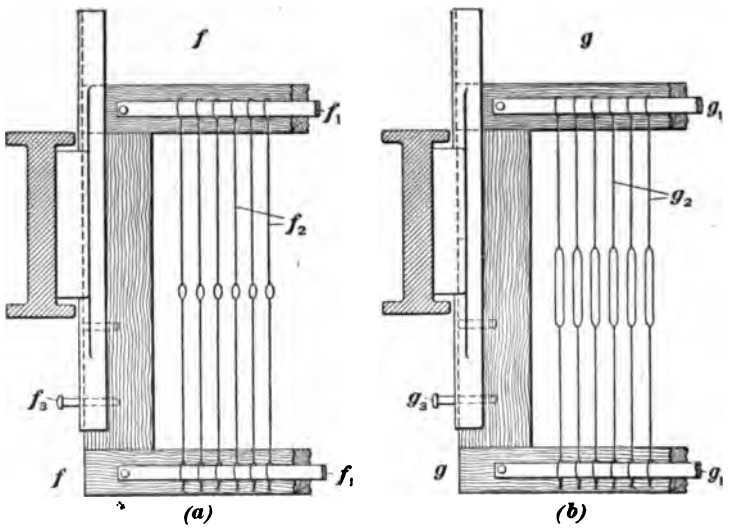


FIG. 5

Each heddle consists of a twisted, tinned, steel wire that has an eye at the center, as well as eyes at the top and bottom through which the rods f_1, g_1 are passed. In the harness for the thread lease, this eye is small; but for the pin lease, it is elongated. These frames are supported at each end by an iron bracket containing a vertical slot; the brackets are attached to the iron beams that form the upper part of the

sides of the machine. The frames may be moved up or down in the vertical slots and when in the position required are held by means of pins similar to f_1 and g_1, at each end of the frame; these pins project through a hole in the bracket into one of two holes in the frame. The harnesses may therefore be secured in any one of three positions, according to whether the pins are in the upper or lower holes or beneath the frames. When a lease is not being taken the pins are inserted in the lower holes, which raises the harness so that the central eyes in the heddles are directly in the path of the yarn as it passes through the warper, thus offering the least possible resistance.

In the harness for the thread lease, the number of heddles is equal to one-half the number of ends that it is possible to warp on the machine. Each alternate end of warp is passed through one of the eyes; the other ends pass between the heddles. For instance, the first, third, fifth, and all odd-numbered ends, counting from one side of the machine, will pass through separate eyes, while the even-numbered ends—the second, fourth, sixth, etc.—will pass between the heddles. The harness for taking the pin lease does not carry so many heddles, since the yarn must be leased in groups of 2, 3, 4 ends, or more. In case the harness frame is arranged for 4-end pin leasing, the number of heddles will be one-eighth the number of spools that the creels are capable of holding, and the ends will pass through the pin-leasing harness in groups of 4 ends each—the first 4 ends through the first eye, the next 4 ends between the first and second heddles, the third group of 4 ends through the second eye, the fourth group of 4 ends between the second and third heddles, and so on.

10. Thread Lease.—When it is desired to take a **thread lease**, the machine is stopped, the pins in the ends of the harness frame f, Figs. 2 and 5 (a), are withdrawn, and the frame is allowed to drop a couple of inches, when the pins are inserted in the upper holes. The lowering of the harness allows a shed to be formed so that a lease

band can be passed between the two sheets of ends, for which a long, round or oval stick with a slot in each end is generally used. One end of the lease band is attached to the slot in one end of this stick, and the stick and band are passed through the shed, after which the end of the band attached to the stick is removed and the stick withdrawn. The band is longer than the width of the sheet of ends and consequently its ends hang down slightly at each side. The pins at the ends of the harness are now withdrawn, the harness is raised, and the pins inserted beneath it, thus holding it in the required position. Raising the harness raises the set of ends that was previously depressed, and thus another shed is formed and another band inserted in the manner previously described. The harness is then lowered into its original position, so that all the ends form one even sheet, after which the ends of the bands are tied together. This completes the taking of the lease and if it is not desired to take a pin lease as well as a thread lease, the machine is started again. The lease bands should always be inserted in front of the leasing mechanism; otherwise they cannot pass forwards with the yarn, because they will come in contact with this mechanism. Fig. 6 (*a*) shows the arrangement of the threads at the lease band when a thread lease is taken.

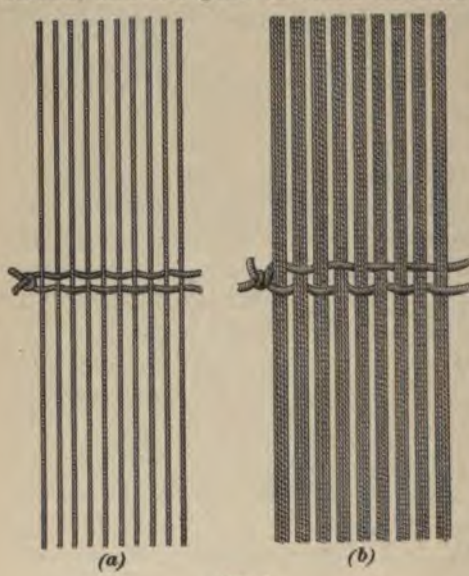


FIG. 6

11. Pin Lease.—The pin lease is taken in the same manner as the thread lease except that the harness *g*, Figs. 2

and 5 (*b*), is used instead of the harness *f*. The arrangement of the threads in a 4-end pin lease is shown in Fig. 6 (*b*).

Another method of taking a pin lease is to adopt the pin-leasing arrangement shown in Fig. 7 (*a*) and (*b*), (*a*) being a perspective view and (*b*) a sectional elevation. This is a rigid, rectangular wooden framework that is attached to the machine and consists of a top rail *a* and a bottom rail a_1

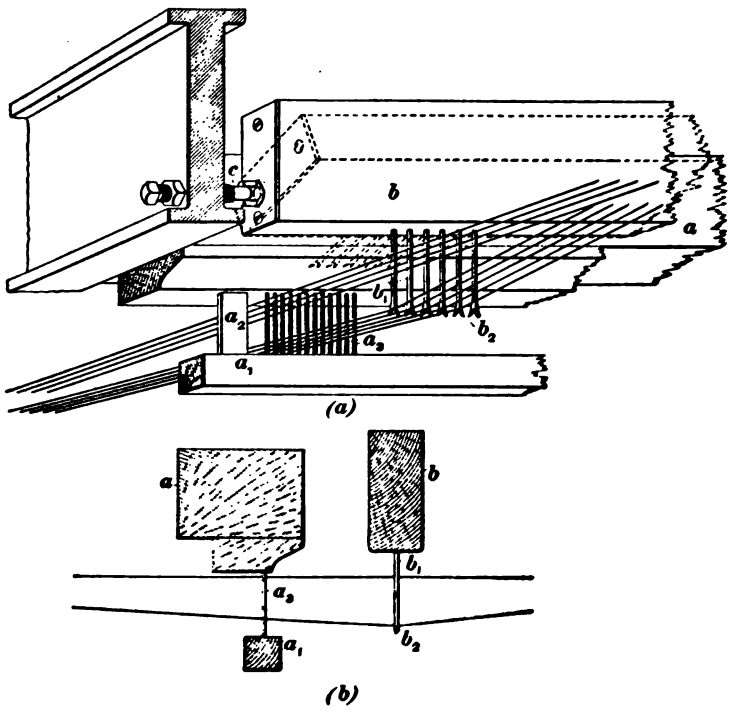


FIG. 7

connected by a wooden bar, similar to a_1, at each end. Iron pins a_3 extend from the top rail to the bottom rail, fitting into sockets in each rail; they are placed 3 pins to the inch. Directly in front of the top pin rail is a wooden block *b* that has securely fitted into it pins b_1 that are twice as far apart as the pins in the pin rail. The lower ends of these pins, instead of fitting into another block, are flattened and spread

with a notch cut in each, thus forming a fork b_2. The wooden block b is mounted on a stud, similar to c, at each side of the machine; these studs are below the center of gravity of the block, so that when out of use it automatically falls into the position shown in dotted lines, raising the pins b_1 out of contact with the yarn. Usually the pin lease must be taken in groups of 4 ends, in which case the yarn is threaded between the pins of the pin rail in groups of 4 ends. In order that all parts may be clearly seen only one end is shown as passing between each two pins in the pin rail in Fig. 7 (*a*). When the correct length has been warped and it is necessary to insert a pin lease, the block b is turned from the position shown in dotted lines to the position shown in full lines, thus moving the forked pins downwards so as to press on those groups of yarn that pass through alternate spaces in the pin rail. By this means alternate groups of 4 ends can be pressed below the normal level of the yarn, thus forming a shed through which the lease band may be passed. The wooden block b is then turned into the position shown by the dotted lines and moved sidewise a distance equal to that between two pins in the pin rail, and again turned down. In this case, it will press down those groups of ends that were left up before and form another shed, through which the lease band is passed and its ends tied to the ends of the band previously inserted, thus giving a means of dividing the warp into groups of 4 ends after it has been passed through succeeding processes.

12. After the lease has been taken, the warper tender starts the machine slowly until the portion of the chain containing the lease bands passes forwards and arrives at the rear of the linker head. The machine is then stopped and the tender raises the weight arms m_3, Figs. 2 and 8, together with the weight m_4, by pulling down the cord m_5 far enough to allow the hook at its lower end to be caught under a suitable portion of the framework of the head; this raises the weight and levers high enough to remove the entire pressure of the weight from the top calender roll m. After this

has been accomplished, the linker head is thrown out of gear, so that the chain will not be linked until after the lease band has passed through the guide tube p, by turning the collar w with the handles w_1 in the required direction to relieve the pressure of the collar w_2 against the hub of the gear r. The attendant then starts the machine slowly with one hand and with the other draws the chain through the calender rolls m, m_1 and the guide tube p until the lease band has passed through the guide tube, after which the linker head is put into gear and the machine is allowed to run until another lease is to be taken, when the operation previously described is repeated.

ROLLS

13. The **measuring roll** h, Figs. 2 and 3, is a hollow, cast-iron, cloth-covered roll, 24 inches in circumference. Immediately above it, with its ends revolving between vertical guides, is another cast-iron, cloth-covered roll h_1 of the same size, that presses heavily on the measuring roll so as to grip each warp end and thus draw the yarn at an even rate from the spools in the creels. The upper roll, which is not shown in Fig. 3, is driven by friction from the lower one, and the object of covering both with cloth is to prevent damage to the ends of yarn and yet secure sufficient pressure to draw them evenly. The return roll j is a plain iron roll. The lower flanged **calender roll** m_1 is on the shaft m_3; the upper one m is a small leather-covered roll supported in position by suitable vertical guides and weighted by means of levers similar to m_2, which carry a weight m_4. When the machine is in operation, the upper roll is held down by means of the weighted levers, so as to secure a sufficient pull on the chain passing between the two rolls; but, when so desired, the weight and levers can be raised by pulling a cord, thus removing any tension on the warp and preventing its being carried forwards. Between the return roll j and the calender rolls m, m_1 is an arched rod k and an inverted fork k_1 to collect the sheet of yarn into a chain immediately before it passes between the calender rolls.

As the yarn leaves the calender rolls, it may be allowed to fall, without being linked, into a bag suspended by hooks; or it may be passed through a linker and put up in linked form, thence falling into a bag or other receptacle, or being deposited in a pile on a piece of burlap on the floor until the chain has been completed, when it is coiled up and tied ready for baling. Besides these forms, the chain may be conducted to a balling attachment and wound in the form of a ball without being linked.

LINKERS

14. A linker is an attachment applied to a warper for the purpose of making links in the chain, and may be either a single or a double linker. A single linker makes a link of three thicknesses of the chain, while with a double linker five thicknesses of chain form the link. In other words, in single links the chain is reduced to about one-third its length, and in double links to about one-fifth its length. Single linkers are now seldom used, as the double linkers are considered better.

The linker on the machine under description is of the double-linker type and is shown in perspective in Figs. 1 and 8. It is attached to the front of the warper, as shown in Figs. 1, 2, and 3, and consists mainly of the framework n, Fig. 8, for supporting the various parts, such as the calender rolls m, m_1, the guide tube p, the necessary hooks, etc., for linking the chain, and the driving mechanism for operating the various parts of the head.

The guide tube p moves in and out around two pairs of hooked arms q, q_1 and hooks q_2, q_3 in the form of a figure 8. Four positions of the tube, arms, and hooks, together with the chain as it is operated on by them, are shown in Fig. 9 (a), (b), (c), and (d). In Fig. 9 (a), the tube is midway between the hooked arms q, q_1 and is ready to start on its outward movement so that it may pass around the hooked arms q_1, as shown in Fig. 9 (b). Fig. 9 (c) shows the tube in position midway between the arms q, q_1 ready to start on

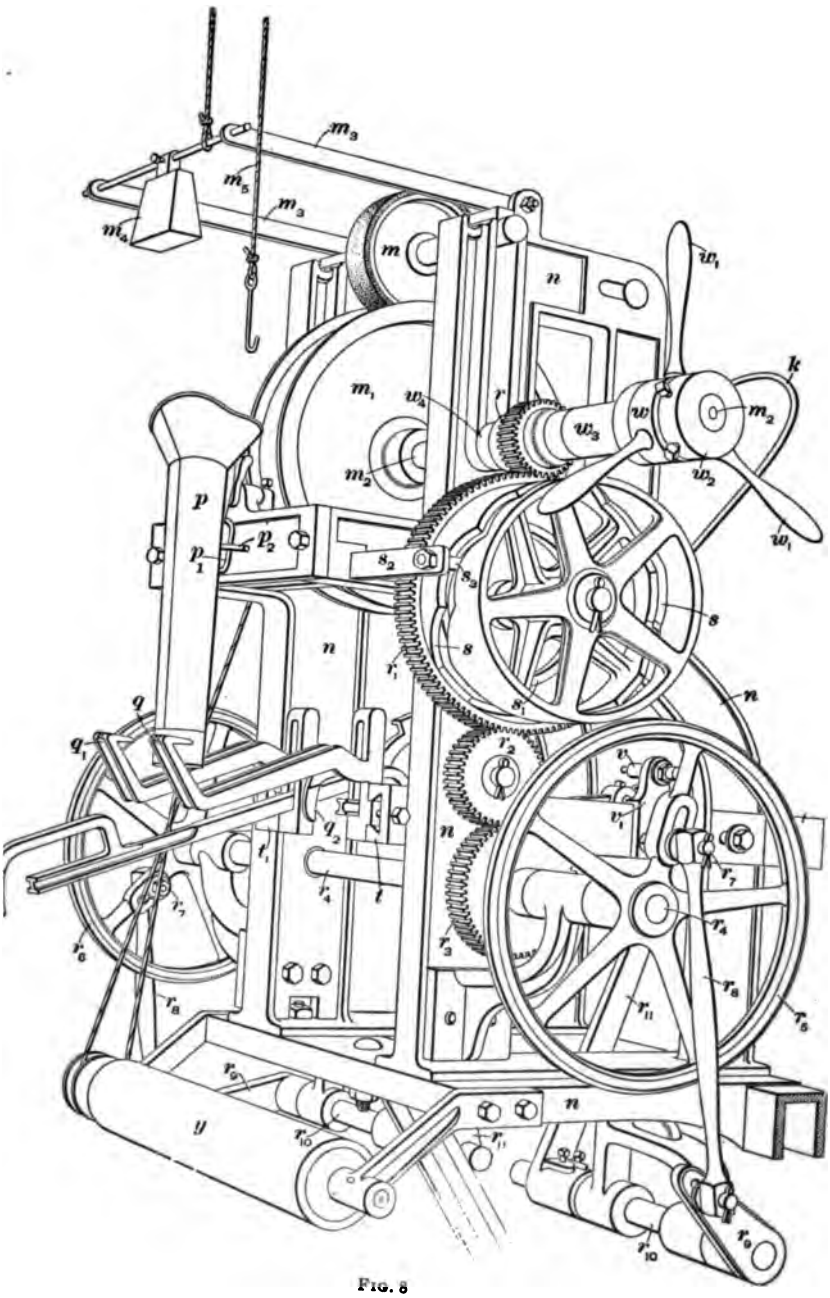

m3
m5
m4
m2
m
n
w1
k
m1
w4
r
w3
w
m2
w2
p
p1
p2
s2
s3
s
n
r1
s1
q
q1
r2
n
q2
t1
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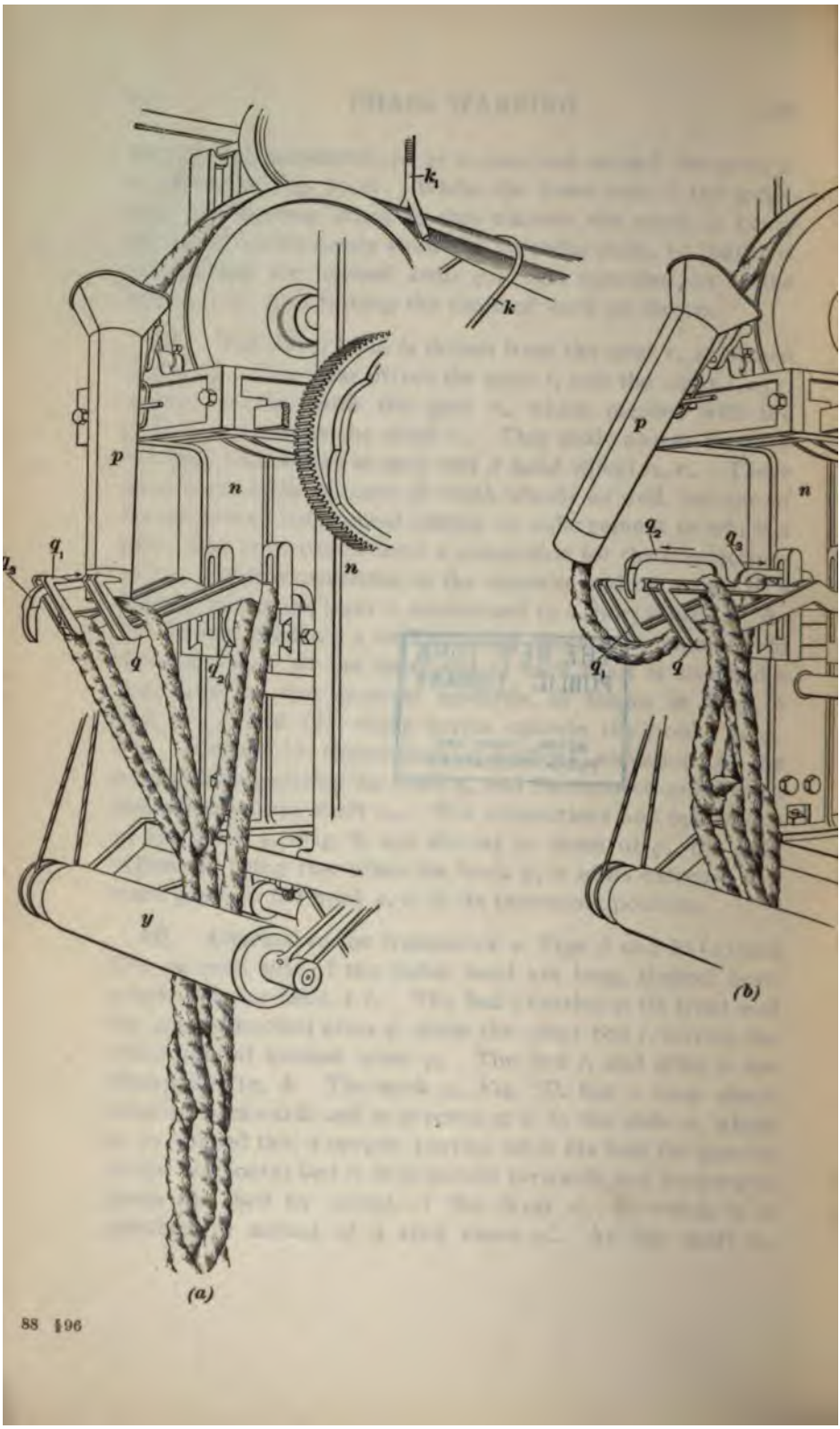
FIG. 8

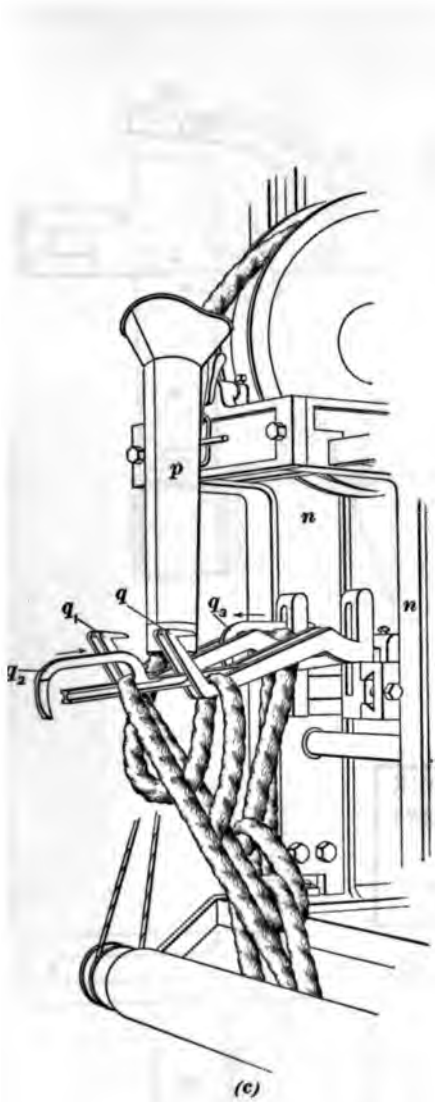
its outward movement so as to pass out around the arms q, as shown in Fig. 9 (*d*). While the lower end of the guide tube p is moving about in this manner, the chain is being delivered continuously from the calender rolls, so that it is laid around the hooked arms q, q_1 and operated on by the hooks q_2, q_3, thus linking the chain of ends as shown.

15. The linker head is driven from the gear r, as shown in Fig. 8. This gear drives the gear r_1 and the cams s, s_1; r_1 in turn, meshes with the gear r_2, which meshes with the gear r_3 situated on the shaft r_4. This shaft passes through the head and carries at each end a hand wheel r_5, r_6. These wheels serve the purpose of crank-wheels as well, for one of the spokes of each wheel carries an enlargement in which a short stud is placed to form a connection for the connecting-rod r_7, which is connected at the opposite end by means of a similar stud to the lever r_8 setscrewed to a short shaft r_{10}. As the wheels revolve, a reciprocating motion is imparted to the shafts r_{10}. At the inner end of each shaft is attached a long lever r_{11} that projects upwards, as shown in Figs. 8 and 10 (*a*) and (*b*); these levers operate the hooks q_2, q_3. Fig. 10 (*a*) and (*b*) shows interior sectional elevations of the mechanism operating the hook q_2, and the connection between the latter and the shaft r_{10}. The connections and operations of the hook q_3, Fig. 8, are similar to those of q_2, the only difference being that when the hook q_2 is in its extreme outward position the hook q_3 is in its innermost position.

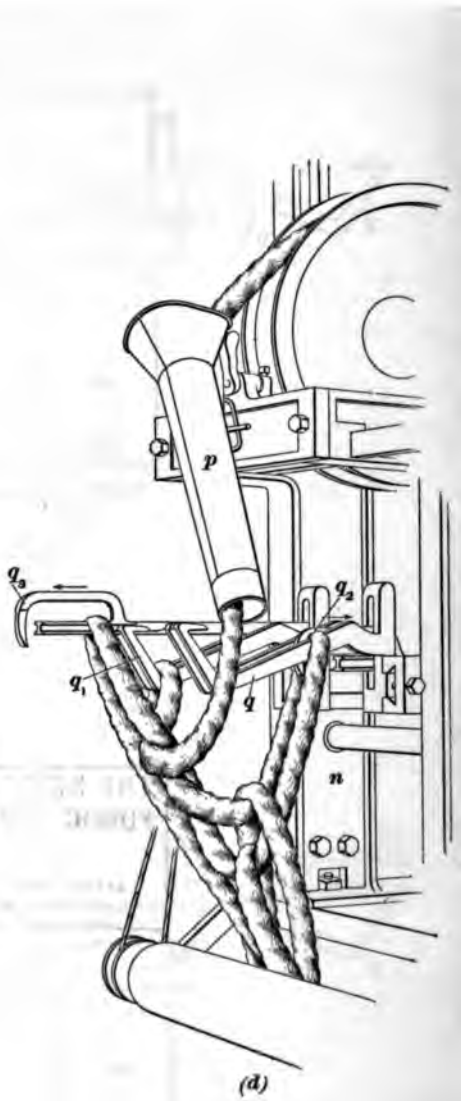
16. Attached to the framework n, Figs. 8 and 10 (*a*) and (*b*), on each side of the linker head are long, slotted, horizontal rails, or beds, t, t_1. The bed t carries at its front end the pair of hooked arms q, while the other bed t_1 carries the other pair of hooked arms q_1. The bed t_1 and arms q_1 are shown in Fig. 8. The hook q_2, Fig. 10, has a long shank running backwards and is pivoted at u_1 to the slide u, which is so shaped that a certain portion of it fits into the groove in the horizontal bed t; it is moved forwards and backwards along this bed by means of the lever r_{11}, to which it is attached by means of a stud screw u_2. As the shaft r_{10}

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TILDEN


k_1
k
p
n
n
q_1
q_2
q
q_2
y
(a)
p
n
q_2
q_3
q_1
q
(b)

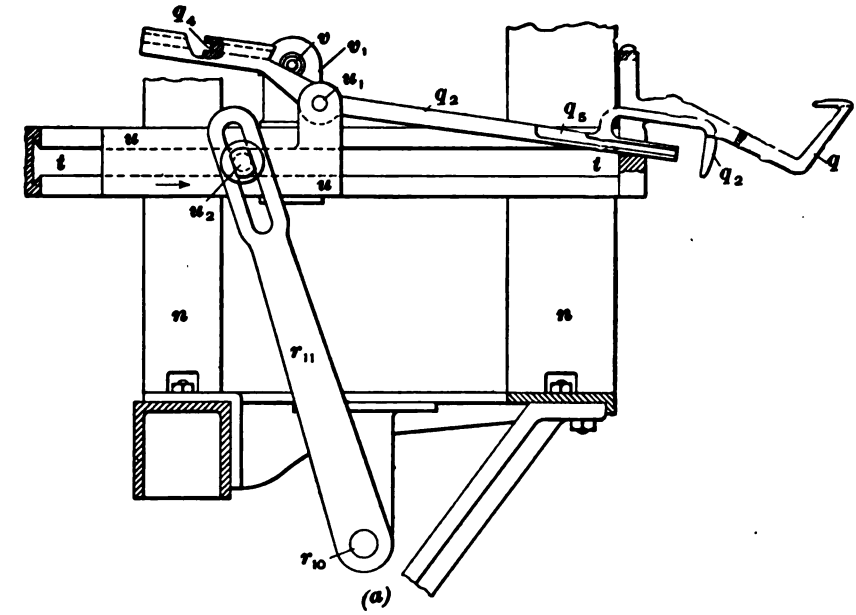


(c)

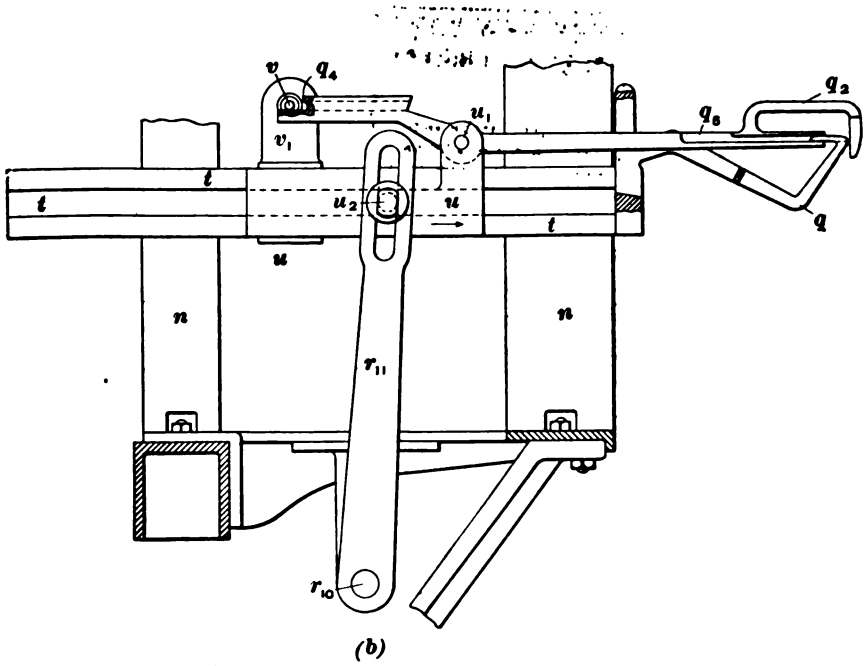


(d)


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ASTOR, LENOX AND
TILDEN FOUNDATIONS.


q_4
v
v_1
u_1
q_2
q_5
q
q_2
u
t
u
t
u_2
n
n
r_{11}
r_{10}

(a)


v
q_4
u_1
q_2
q_5
v_1
t
t
u_2
u
l
q
u
n
n
r_{11}
r_{10}

(b)

FIG. 10

oscillates, a reciprocating motion is imparted to the slide u. Since the hook q_3 is pivoted to this slide, both move in and out together.

17. In Fig. 10 (a), the hook q_3 is shown in approximately the same position as in Fig. 8. When the slide begins to move outwards, the hook must be raised, so that the long straight shank will be in a horizontal position. The raising of the hook is accomplished by means of the pin v, which is supported by the bracket v_1, coming in contact with the inclined portion of the hook shank near the point at which it is pivoted. As the slide u moves outwards, as shown by the arrow, the pin v gradually forces down the inner end of the hook and consequently raises the outer end until the pin v projects into the horizontal slot q_4, thus causing the hook, together with its long, straight shank, to occupy a horizontal position while moving outwards. The hook, as it moves outwards, is in the proper position to allow the grooved part, which is shaped as shown in Fig. 8, to pass on to the horizontal prongs of the hooked arms q, as shown in Fig. 10 (b). This passage takes place just before the pin v leaves the slot q_4. With its outer end retained in this manner, the hook will occupy a horizontal position until it has moved outwards a sufficient distance to allow the opening q_3 to pass over the horizontal prongs of the hooked arms q, thus allowing the outer end to drop, as there is nothing to hold it in place. The extreme outward movement of the hook is completed at this point and it now returns and assumes its innermost position. This movement is accomplished by the backward movement of the upper end of the lever r_{11}. As the hook moves inwards, the lower edge of the inclined portion of the shank near the pivot u_1 comes in contact with the pin v and forces it into its supporting bracket, thus allowing the hook to pass beyond and the pin to protrude from the bracket again. Thus it will be seen that the pin has a slight lateral movement, being caused to project from its supporting bracket by a spring. When the backward movement is completed, the lever r_{11}

starts to move forwards again, carrying with it the hook q_2 so that the pin v again comes in contact with the upper edge of the short incline of the hook, thus raising it into a horizontal position, when the cycle of operations is again repeated. This movement continues, in order that the chain may be linked as it is delivered by the guide tube.

As the hook q_2 moves inwards, it carries a portion of the chain with it, as shown in the first position, Fig. 9 (*a*); then as the hook starts to move outwards the portion of the chain that was carried back is carried forwards, as shown in the second position, Fig. 9 (*b*), and finally passed over the prongs of the hooked arms q, and drops with the hook q_2, as shown in the third position, Fig. 9 (*c*). The hook now starts to move backwards, and as it does, the portion of the chain that has thus been acted on comes in contact with the lower front part of the pair of hooked arms q, where it is retained, as the space between these is not large enough to allow it to pass. It remains in this position until the end of the grooved part of the hook has passed and allows it to drop. As the hook continues its inward movement, it catches the portion of the chain that rests over the arms q and carries it backwards, as shown in the fourth position, Fig. 9 (*d*), until it occupies the position of the chain shown in the first position, Fig. 9 (*a*). While this hook has been at work, the hook on the opposite side of the head has been working in a similar manner, except that it reaches its extreme outward position when the first one has reached its innermost position, and vice versa. The guide tube p has also been at work during these operations, laying the chain around the hooked arms q, q_1, so that it is in the correct position to be acted on by the hooks q_2, q_3.

18. The guide tube p, Fig. 8, is operated by means of the cams s, s_1 and a combination of slides and levers. It is attached to the framework n near its upper end by a swinging hinge, which is operated by means of the sliding bar s_2, the cam-bowl s_3, and the cam s, so that it has a side movement due to the shape of the cam-course. The inward and

outward movement is accomplished by the cam s_1, which operates, through a combination of levers, the pin p_3 that pushes out the tube and draws it in again. This pin passes through a wire loop p_1, which is attached to the guide tube. The combined action of the cams s, s_1, together with their connections with the guide tube p, is such as to cause the lower end of the guide tube to move in a path around the hooked arms q, q_1 corresponding to the shape of a figure 8.

19. The linker head can be thrown in or out of gear while the machine is running by turning the collar w, Fig. 8, by means of the handles w_1. Throwing the linker out of gear does not stop the delivery of the chain, as the calender rolls continue to revolve as long as the remainder of the machine is in operation; it merely stops the linking mechanism so that the chain is delivered without being linked. The collar w is threaded on the inside and works in a short thread on the shaft m_2. The outer end of the shaft m_2, as shown, carries a collar w_2 that is firmly setscrewed to it; the position of this collar governs the extreme outward movement of the threaded collar w. On the same shaft with these two collars is a long collar, or sleeve, w_3, one end of which is in close proximity to the collar w, and the other to the hub of the gear r when the head is out of gear. Fastened to the shaft on the opposite side of this gear is a small collar w_4. When it is desired to throw the head into gear, the collar w is turned by means of the handles so that it is moved toward the framework n. Moving the collar in this direction forces the sleeve w_3 toward the gear, and a continued movement forces the gear slightly nearer the framework until it is firmly held between the collar w_4 and the sleeve w_3, thus causing it to revolve with the shaft m_2 until the pressure is relieved by turning the collar w in the opposite direction. Fig. 8 shows the various parts in their proper positions when the head is in gear.

The roll y, Figs. 8 and 9 (a), simply serves as a guide roll to guide the chain as it passes downwards after it has been linked. It is driven by a small band from a grooved pulley

on the shaft m_1. As the chain passes the guide roll y, it is usually deposited on a piece of burlap spread on the floor for that purpose; after the chain has been completed, it is ready to be coiled and baled, or put up in any other convenient manner. Sometimes it is delivered directly into bags or trucks. Linked chains are not made to such an extent at present as formerly, the tendency being more toward the production of balled chains.

BALLING ATTACHMENT

20. In case it is desired to ball the chain instead of linking it, the yarn after passing through the calender rolls m, m_1, Fig. 2, is carried downwards at an angle under the warper, through a guide, around a return wheel, and thence forwards to a **balling attachment** fastened to the floor at the front of the machine. The return wheel is usually situated about midway between the upright standards of the machine when only one balling attachment is applied. As is shown in Fig. 11, it consists of the bed a that is securely fastened to the floor, the stand a_1, fastened to the bed and supporting the return wheel b, and an adjustable guide b_1.

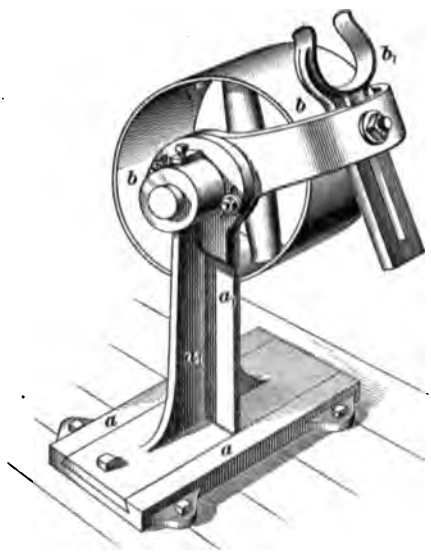


FIG. 11

The balling attachment proper is similar to that used on the ordinary type of balling warper so far as the main mechanism and construction are concerned; the principal difference is in the method of driving. The attachment shown in Fig. 12 is the type generally used in connection with the Denn warper

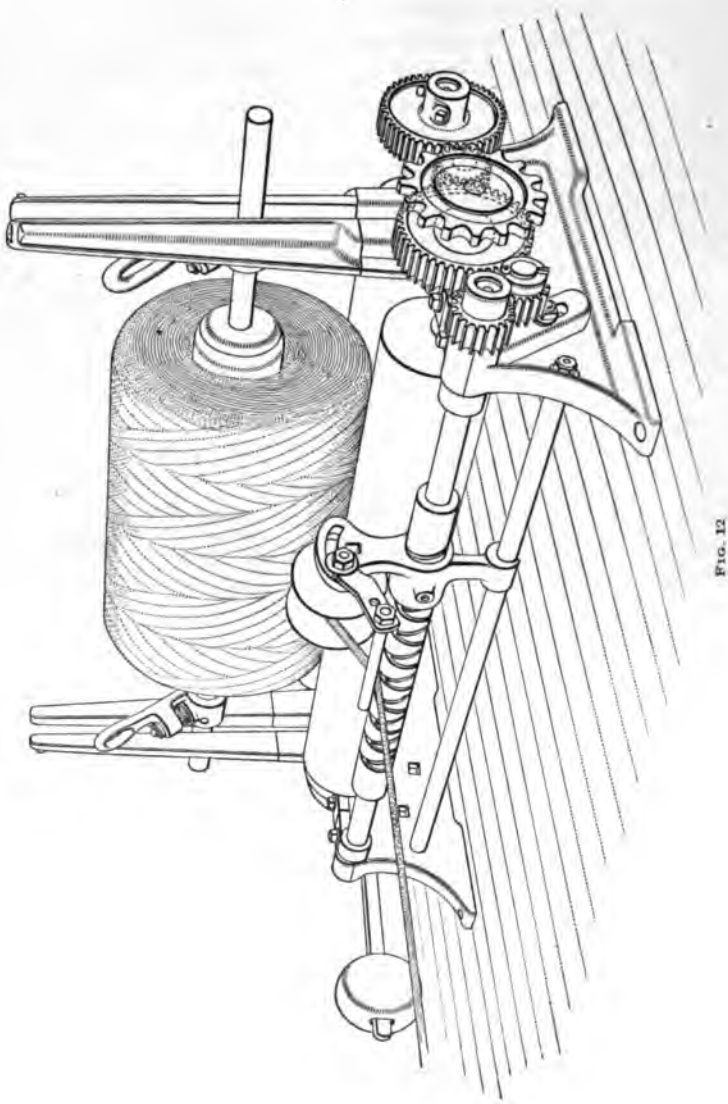


FIG. 12

for making balled chains. It is driven from the large sprocket gear m_6 on the shaft m_2, Fig. 3, by means of a chain driving a small sprocket gear, as shown in Fig. 12. In this case no slow-motion mechanism is applied, the balling attachment being positively driven at a uniform speed.

MEASURING MOTION

21. As the chains must always be made of a specified length and usually consist of a definite number of cuts, at the completion of some of which lease bands must be inserted, it is necessary to have some arrangement on the Denn warper to indicate when the required length for each cut has been warped, when lease bands should be inserted, and also when the entire chain has been completed. In addition to notifying the operator at these points, it is of advantage to have the machine stop automatically, because of the necessity of inserting lease or cut bands at certain places.

The details of the measuring motion are shown in Figs. 13 and 14; the single-threaded worm h_4, also shown in Fig. 3, on the cross-shaft e_2 drives the worm-gear h_5, which in the machine under description has 78 teeth and is on the same shaft with the gear h_6 of 27 teeth; h_6 drives, through a carrier gear, the gear h_7 of 78 teeth, which is fastened on the shaft h_8 known as the *striker shaft*. The gears h_5, h_6, h_7 are change gears that must be altered when it is required to measure different lengths between cut marks, between lease bands, and for the entire warp. On the same shaft with the gear h_7 is a collar that carries a pin h_9, which at a certain point in the revolution of the gear h_7 presses against the end of a wire rod h_{10} carrying a bell h_{11}. This pressure is not removed until the pin is carried around far enough to release the end of the rod h_{10}, which is then pulled back suddenly by means of the spring h_{12}, consequently ringing the bell; the curves in the wire supporting the bell tend to prolong the vibrations and intensify the sounding of the alarm. This takes place at the end of each cut.

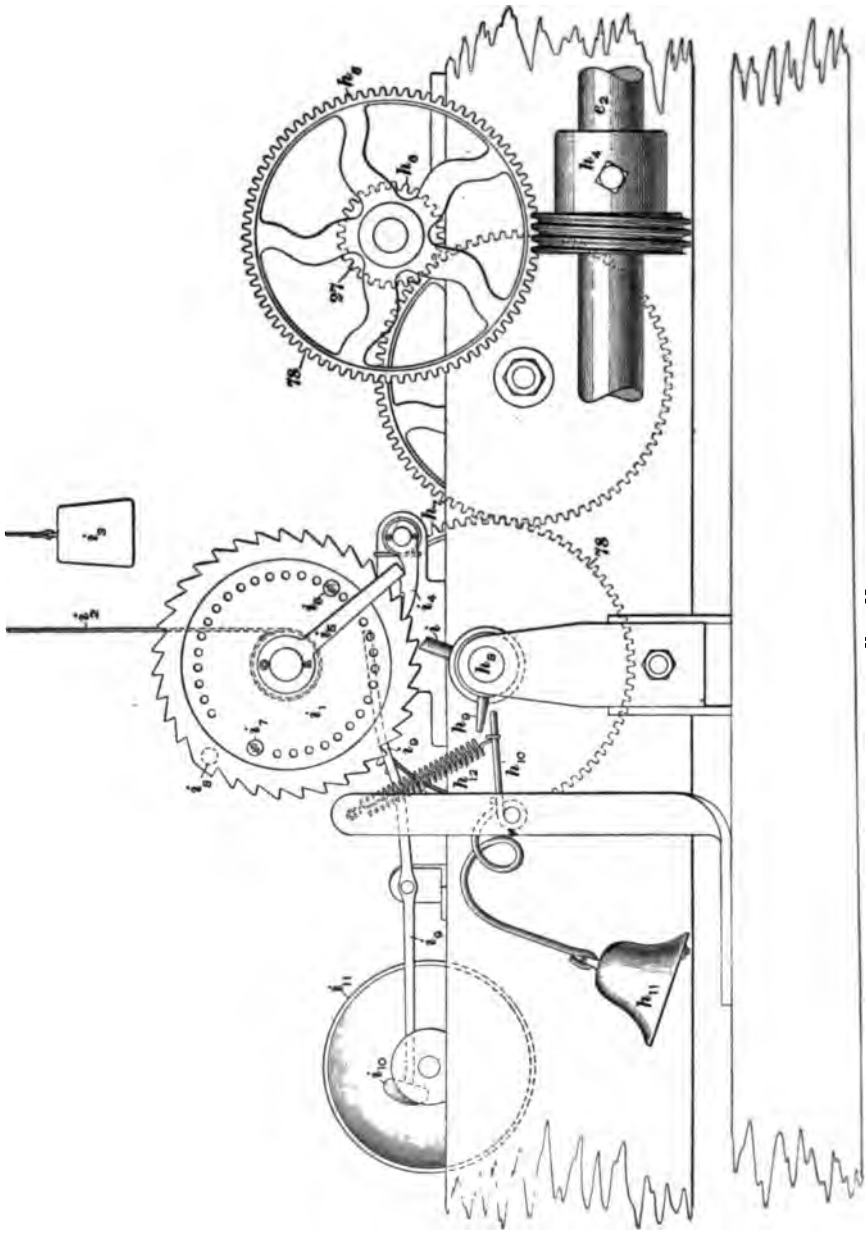

h_8
h_9
97
78
e_2
h_4
i_3
i_2
h_{12}
i_5
i_4
h_5
i_1
i_7
i_6
h_6
h_7
h_{13}
h_{10}
i_9
i_{11}
i_{10}
h_{11}

FIG. 15

22. At the same time that the bell is sounded, a pin i that is attached to the striker shaft h_s in a similar manner to the pin h_p, moves the disk i_1 a distance of 1 tooth. This disk is mounted on a short stud and consists of a plate with ratchet teeth on its outer edge and a series of holes arranged

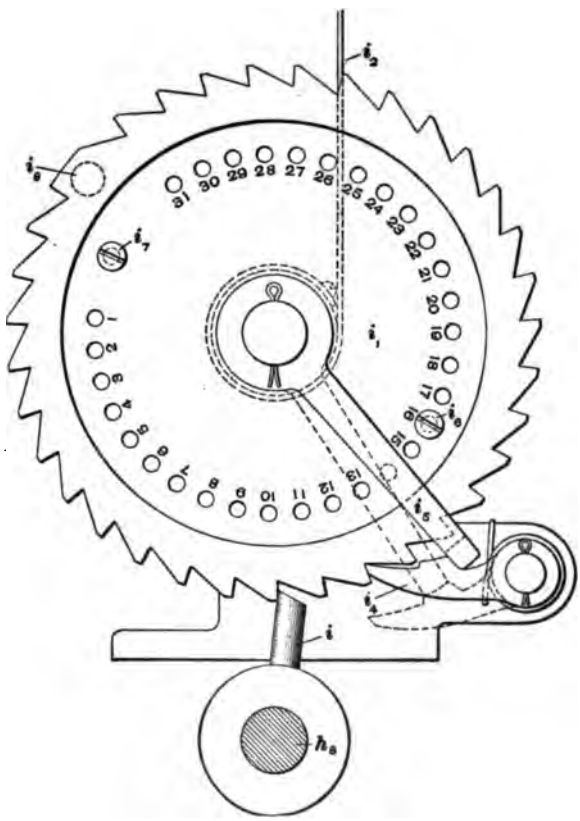


FIG. 14

in a circle in its inner part. Around the hub of the disk is wound a cord, or strap, i_2, that passes upwards over a pulley and carries at its other end a weight i_3; the tendency of the disk, therefore, when released, is to revolve in the opposite direction to that in which it is moved by the operation of

the pin, because the pressure, or pull, of the weight tends to unwind the cord i_2 from its hub. The pawl i_4 is held in contact with the teeth of the disk by means of a spring, and holds it in position after the pin moves it forwards 1 tooth at each revolution of the striker shaft h_4. Hanging from the stud on which the disk i_1 is mounted is a long arm i_6 with its lower end resting loosely on the pawl i_4. A pin i_8 may be placed in any one of the 31 holes of the disk, its position determining the number of cuts required between lease bands. In case there should be 16 cuts between leases, the pin is placed in hole number *16*, as shown in Fig. 14. When the striker shaft has made 16 revolutions, it will have moved the disk 16 teeth and brought this pin in contact with the hanging arm i_5. This will press down the arm and with it the pawl until they occupy the positions shown in dotted lines in Fig. 14; the arm in this case rests against an enlarged portion of the pawl, thus holding it entirely out of contact with the disk. When this takes place there is nothing to prevent the disk revolving backwards in consequence of the pull of the weight i_3. It continues its backward movement until the pin i_7 strikes the arm i_6 and removes it from the projection on the pawl i_4, which allows the pawl to come in contact with one of the teeth of the disk i_1, thus preventing its turning any farther in this direction. The pawl stops the disk in the proper position for starting another chain. This backward movement of the disk allows the cord i_2 to be unwound from its hub and the pin i_8 to come in contact with one end of the lever i_9, thus causing the opposite end, which carries a hammer i_{10}, to rise and strike the gong i_{11}. This notifies the operator that the required number of cuts has been warped, when he should stop the machine and insert the lease bands.

23. In the later styles of Denn warpers, which are supplied with electrical stop-motions to stop the machine in case of the breakage of an end, electricity is also applied to the measuring motion, by using a rack in place of the disk. The striker shaft moves the rack 1 tooth at the completion of each

cut, as in the case of the measuring motion with the circular disk; but when the rack has been moved a sufficient distance to bring a projecting rod situated at the end of the rack against another rod attached to a stationary part of the machine, an electric bell is rung to notify the attendant, and the warper is stopped automatically. The advantage of this is that in the event of the attendant being otherwise engaged or inattentive, if the complete length of chain has been made, the machine stops automatically and thus prevents the formation of a longer chain than is required, as happens with the arrangement shown in Fig. 13, which merely rings the gong and does not stop the machine.

CALCULATIONS

24. Calculations for Measuring Motion.—The calculations necessary for the Denn warper are limited as compared with those for other textile machines. The only ones of importance are for the measuring motion and the weight of the chain.

25. To find the number of yards in a cut when the circumference of the measuring roll, the connecting gearing between the measuring roll and the driving shaft, and the sizes of the gears in the measuring motion are known:

Rule.—*Considering the gear on the end of the measuring roll as a driver, multiply the circumference of the measuring roll by the product of the driven gears and divide by the product of the driving gears multiplied by 36 (the number of inches in 1 yard).*

EXAMPLE.—Find the number of yards in a cut for a warper geared as shown in Figs. 3 and 13.

SOLUTION.— $\frac{24 \times 18 \times 26 \times 78 \times 78}{54 \times 26 \times 1 \times 27 \times 36} = 50.074$ yd. per cut. Ans.

26. The length of cut desired may sometimes require that only one of the change gears h_1, h_2, h_3, Fig. 13, be changed, while in other instances two or even the entire three gears must be changed. To calculate the change gear, a constant may be found for any one of these gears.

To find the constant for finding the length of a cut or the size of the gear required to produce a cut of a given length, the sizes of the various gears being known:

Rule.—*Apply the rule for finding the number of yards in a cut, considering the change gear as having 1 tooth.*

EXAMPLE 1.—Find the constant for the measuring motion according to the gearing in Figs. 3 and 13, considering the gear h_6 as the change gear.

SOLUTION.— $\frac{24 \times 18 \times 26 \times 78 \times 78}{54 \times 26 \times 1 \times 1 \times 36} = 1{,}352$, constant. Ans.

EXAMPLE 2.—Find the constant for the measuring motion according to the gearing in Figs. 3 and 13, considering the gear h_7 as the change gear.

SOLUTION.— $\frac{24 \times 18 \times 26 \times 78 \times 1}{54 \times 26 \times 1 \times 27 \times 36} = .6419$, constant. Ans.

In example 1, the constant is a **constant dividend,** while in example 2 it is a **constant factor.**

27. To find the number of yards in a cut when the constant is a constant dividend.

Rule I.—*Divide the constant by the size of the change gear.*

EXAMPLE 1.—Find the number of yards in a cut with a 27-tooth change gear at h_6 when the constant is 1,352.

SOLUTION.— $1{,}352 \div 27 = 50.074$ yd. per cut. Ans.

To find the number of yards in a cut when the constant is a constant factor.

Rule II.—*Multiply the size of the change gear by the constant.*

EXAMPLE 2.—Find the number of yards in a cut with a 78-tooth change gear at h_7 when the constant is .6419.

SOLUTION.— $78 \times .6419 = 50.068$ yd. per cut. Ans.

To find the size of the change gear required at h_6 when the constant dividend and the number of yards in a cut are known:

Rule III.—*Divide the constant dividend by the number of yards in the cut.*

EXAMPLE 3.—Find the size of the change gear required at h_6 to produce a 50.074-yard cut when the constant is 1,352.

SOLUTION.— $1{,}352 \div 50.074 = 27$-tooth change gear. Ans.

To find the size of the change gear required at h, when the constant factor and the number of yards in a cut are known:

Rule IV.—*Divide the number of yards in a cut by the constant.*

EXAMPLE 4.—Find the size of the change gear required at h, to produce a 50.074-yard cut when the constant is .6419.

SOLUTION.— $50.074 \div .6419 = 78.009$, a 78-tooth change gear. Ans.

28. Calculations for Weight of Chain.—To find the weight of a chain when the total length of the chain, in yards, the number of ends in the chain, and the ply and counts of the yarn are known:

Rule.—*Divide the product of the total length, in yards, the total number of ends in the chain, and the ply of the yarn by the product of the number of yards in a hank and the counts of the single yarn that constitutes the ply yarn.*

EXAMPLE.—Find the weight of a 10,000-yard chain that contains 2,250 ends of 2-ply 20s.

SOLUTION.— $\frac{10{,}000 \times 2{,}250 \times 2}{840 \times 20} = 2{,}678.571$ lb., total weight of the chain. Ans.

ELECTRICAL STOP-MOTIONS AND ANNUNCIATORS

29. Fundamental Principles of Electricity.—A principle that is now frequently applied to warping machines of certain makes is that of automatically stopping the machine through the use of electricity. But before considering **electric stop-motions**, it is necessary to give some attention to certain laws of electricity that make it possible to apply this class of stop-motions to cotton-mill machinery. The electric current must always be generated by some suitable mechanism, which for stop-motions on warpers generally consists of a dynamo placed in some suitable position with relation to the machine. If suitable connections are made, an electric current will flow from the dynamo through the connections back to the dynamo, forming what is known as a *circuit*. In order to have a current of electricity, there must always be a complete route, or

circuit, from the source of the electric current, through the various connections, back to the place from which it started. If there is more than one route that the current can follow, it will divide into two or more currents, but the maximum current will always flow through the path of the least resistance. If for any reason the circuit is broken, the flow of electricity will stop. The two ends, at any place where the circuit is interrupted, are known as *terminals*, one of which is termed *positive* and the other *negative*. The terminal from which the current would flow, if connected with the other terminal, is called **positive**, while the other terminal, into which the current would flow from the positive terminal, is called **negative.**

Substances are divided into two classes according to the resistance they offer to the flow of electricity, known as **conductors** and **non-conductors;** the former consist of those substances through which an electric current can readily pass, such as metals, while the latter comprise substances that offer great resistance to the flow, as, for instance, glass, silk, cotton, etc. When two conductors come in contact, the current readily flows from one to the other. If it is desired to prevent this flow, they must be separated by letting air or some substance that is a non-conductor intervene between them; they are then said to be *insulated*. If, while insulated, it is desired, at times, to establish a connection between them, a device, such as a switch, is interposed between the terminals. As long as the terminals of a circuit, connected with a dynamo in operation, remain insulated, no current will pass through the circuit. The terminals are then said to be *charged*, as they are ready to establish a current the moment a contact is made.

If a piece of soft iron is surrounded by coils of wire through which an electric current passes, the iron becomes magnetized and has the power of attracting certain other metals, such as iron and steel. A piece of iron magnetized in this manner is known as an **electromagnet.** This magnet must be supported by a suitable part of the machine and connected to a dynamo or some other source of electrical energy.

30. Stop-Motions.—In the latest styles of Denn warpers, electrical stop-motions are extensively used in place of the mechanical. Under certain circumstances the electrical motion is simpler and more effective. In case the electric stop-motion is applied to stop the machine when an end breaks, it is usually applied to the creels. The creels used on the machine under description for the electrical stop-motion are different from those used with the mechanical stop-motion. The main parts for supporting the spools are practically the same, but the arrangement in front of each vertical row of spools is like that shown in Fig. 15. In front of the standards a that carry the spools is an additional wooden vertical standard a_1, to which are attached two strips, or bars, of copper b, b_1 that extend from the bottom to the top of the creel. A drop wire c is pivoted on a screw in the bar b_1, so that it is always in electrical contact with this bar. The bars similar to b_1 are connected at the top by means of wires, throughout the entire creel, to other bars running along the creel top, so that they form one terminal of an electrical circuit, while all the bars similar to b, which do not carry drop wires, are also connected and thus form the other terminal. Both terminals are connected with the dynamo by means of conducting wires, and one of these is so connected with the electromagnet z, Fig. 16, that whenever a current is passing between the dynamo and the terminals it will circulate around the electromagnet and energize it.

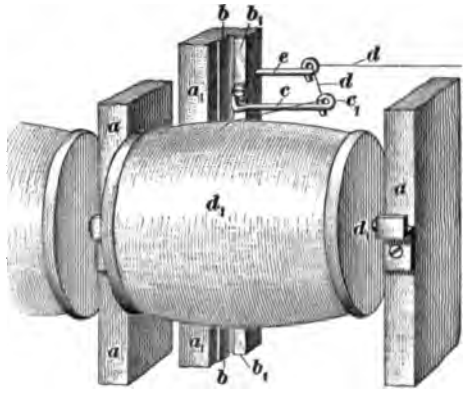


FIG. 15

The end of yarn d, Fig. 15, passing from the spool d_1 is carried through a loop c_1 in the outer end of the drop wire and

thence to a fixed curved guide wire *e* screwed into the standard a_1. The yarn supports the outer end of the drop wire *c* as shown; thus, if the yarn breaks, this end falls and the curved part, or shoulder, of the inner portion is brought in

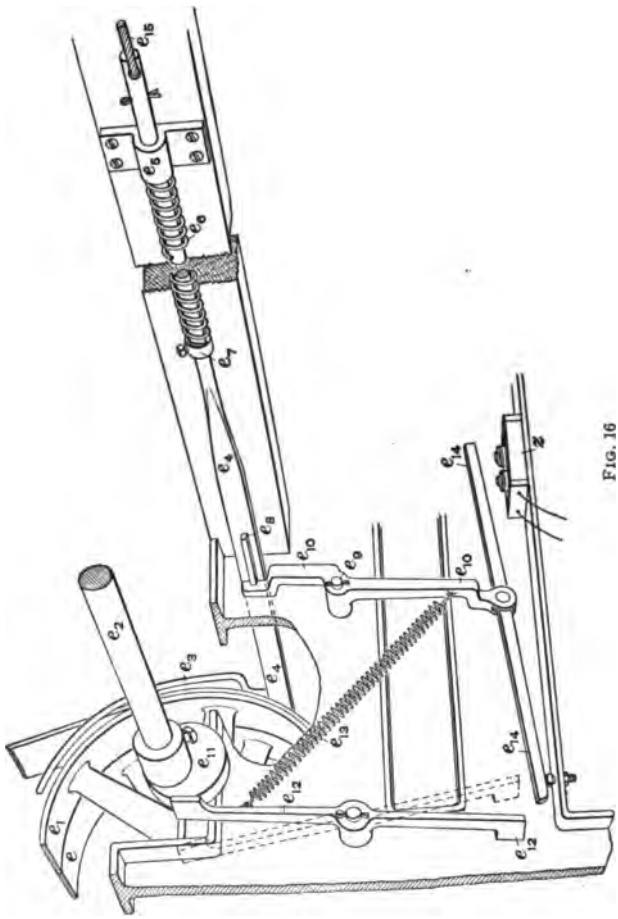


FIG. 16

contact with the vertical strip *b*, thus connecting the two strips *b* and b_1 and allowing the circuit to be completed. With the circuit completed, the electromagnet *z*, Fig. 16, attracts, or draws down, the end of the lever e_{14}, which is pivoted to

the lever e_{14}, so that the other end rises and comes in the path of the lower end of the lever e_{13}, which results in the belt being shipped from the tight to the loose pulley in the same way as with the mechanical stop-motion. The reference letters in Figs. 4 and 16 are the same for corresponding parts. After the end has been pieced up, the circuit is broken again, because the drop wire is held up in position by means of the yarn; the end of the lever e_{14} that is directly over the electromagnet is therefore allowed to rise, because the weight of the opposite end is greater, and as no current is flowing through the electromagnet, the latter is inactive and has no power to attract the lever.

31. In electrical stop-motions that are applied to stop the machine at the completion of a cut, when a lease band is to be inserted, and when the chain is complete, the desired result is accomplished by having the measuring motion so constructed that positively and negatively charged parts are brought in contact when the desired length has been run, thus completing the circuit and stopping the machine by means of the magnet in the same way as explained in connection with the breaking of an end.

32. Annunciators.—When chains contain more than 800 ends, an **annunciator** is also used in connection with the stop-motion for broken ends, to indicate the portion of the creel where the operator can find the broken end. The spools in the creels are divided into a number of groups, usually nine, each with a certain number of rows of spools. The groups are numbered to correspond to a similar number of signals in an annunciator, so that when an end breaks the signal indicating the portion of the creel containing the broken end is shown.

WALCOTT WARPERS

33. The **Walcott warper,** Fig. 17, differs from the Denn warper mainly in the arrangement by which the ends are brought downwards from the creel and warped at a short distance from the floor, affording ready access to the broken ends. The yarn passes from the creel *a*, through an eye

board, or holeyboard, *b*, thence over a measuring roll *c*, under a guide roll *d*, and through the lease reeds *e*, *f* mounted on stands secured to the frame of the warper. The sheet of

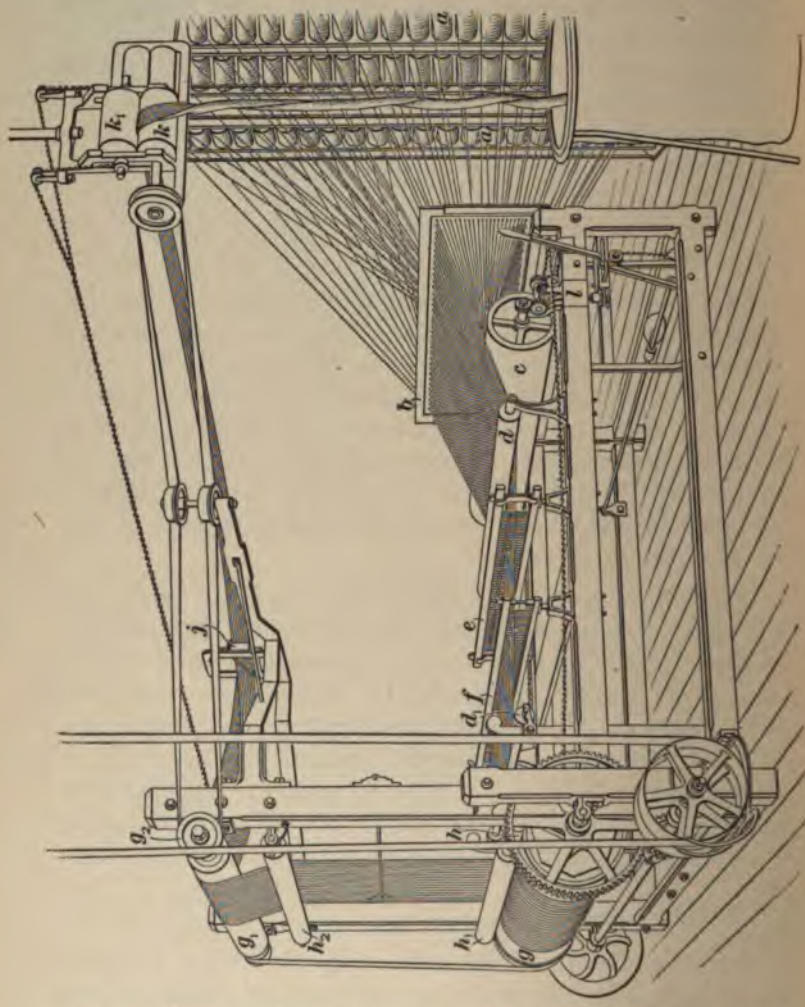


FIG. 17

ends is then conducted over another guide roll d_1, to and around almost the entire circumference of a large roll *g*, called a *draft roll*. This is covered with cloth, and, by

rolls h, h_1 being placed in a suitable position, is given so long a contact with the ends of yarn as to provide a steady and even pull on every end, thus insuring that all the ends shall, as nearly as possible, be the same length in the completed chain. Thence the sheet of yarn passes upwards to the roll h_2 and then around the roll g_1, which has the same circumferential speed as the draft roll g. Up to this point the yarn has been in a wide, evenly laid sheet, but now it is contracted and carried around a guide pulley j and between the condenser, or calender, rolls k, k_1. The upper roll k_1 is self-weighted, i. e., of sufficient weight in itself to draw the chain between the two rolls; it is driven by friction from the bottom roll k, which is driven positively, by means of a belt, from the pulley g_2 on the end of the roll g_1, the direction of the belt being changed by means of guide pulleys, as indicated. The upper roll can be raised when necessary by a chain that is attached to a bearing at each end of the roll. From the condenser rolls, the warp drops into a bag, box, or other suitable receptacle. It is then ready to be put in proper form for shipment, or may be taken out and either linked or balled by means of a linker or a balling machine.

Fig. 17 shows a Walcott warper without a stop-motion, but one can be applied if required. A measuring motion is connected with the measuring roll as shown at l. Any of the types of leases described can be taken on this machine as well as on any other machine. They are generally taken by means of reeds similar to e, f, which are constructed especially for this purpose. Walcott warpers are usually constructed so as to make chains containing up to 1,200 ends and are used chiefly for short chains, although long chains can be made if required. The space occupied by a Walcott warper with a creel for 1,200 spools is 13 feet by 32 feet; its height is $8\frac{1}{2}$ feet.

PROCESSES FOLLOWING CHAIN WARPING

CONVERTING

34. Chains are generally put through a process that changes the appearance of the yarn, either by dyeing, bleaching, or other treatment. The formation of the chain produced by the warping process prevents any unnecessary entanglement during these converting processes, and by means of the leases the relative position of the ends is maintained. It is usually necessary to manipulate in various ways the ends of yarn forming the chain before using the yarn for the purpose for which it is finally intended. The next process depends on whether the chain is a short chain or a long chain, and whether it is to be used for warp or filling. In the case of warp yarn in a short chain, the next process after converting is dressing, or beaming, to the loom beam; in the case of warp yarn in a long chain, the next process is dressing, or beaming, to the section beam; and in the case of filling yarn, the next process is quilling.

BEAMING

OVERHEAD PROCESS OF BEAMING

35. Two principal styles of **dressing**, or **beaming**, machines are used, and the process is known variously as dressing, or beaming, sometimes as dressing and beaming, and sometimes as dry dressing; but as there are a number of other dressing processes in the textile industries, it is much better to speak of the process now under consideration as a beaming process.

A method commonly used for short-chain warps is shown in Fig. 18; it is usually spoken of as the **overhead process**

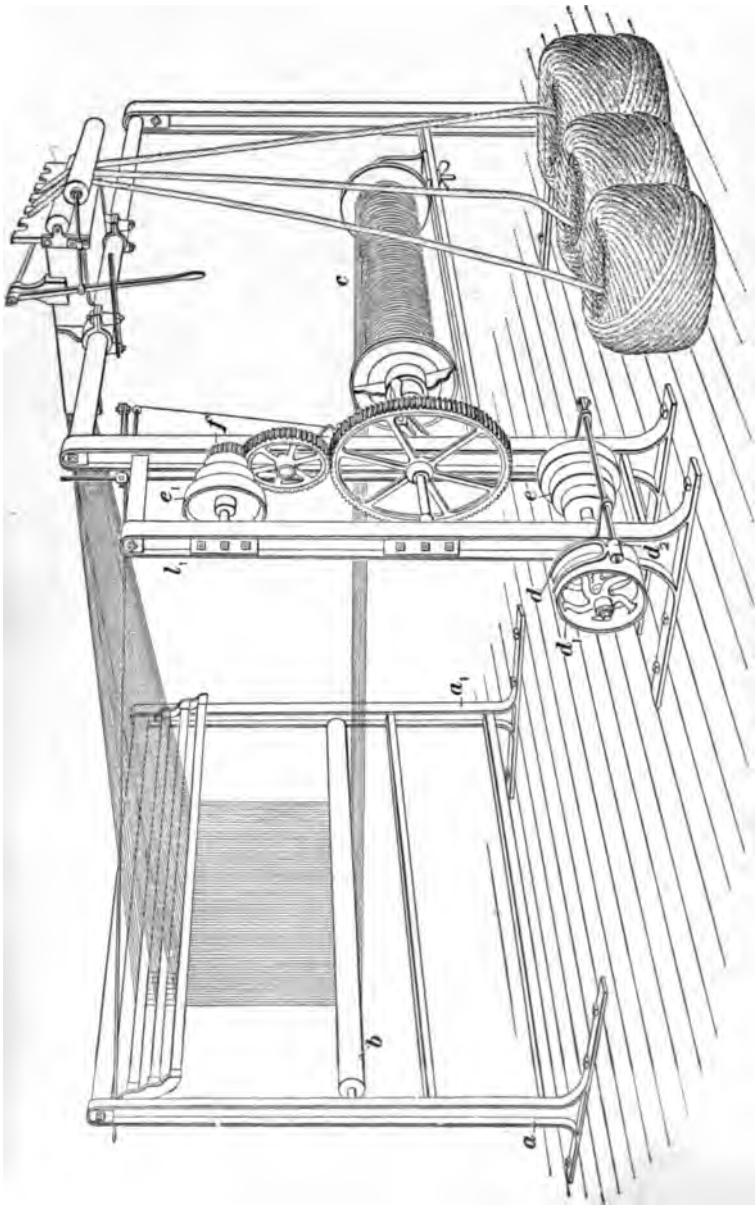


FIG. 18

of beaming, although it is sometimes called **Yorkshire dressing,** after the name of the English county where it is widely in use.

36. Passage of the Yarn.—The chains, shown in ball form, are placed on the floor and passed upwards between two wooden rolls and over a slotted block of wood, after which they are loosely opened out; if they contain bunch-knot leases or bout leases, they are usually divided accordingly, care being taken to arrange the threads in the same relative positions as they occupied when being warped. At a distance of several feet is placed a framework consisting of two stands, or supports, a, a_1, Fig. 18, and three or four wooden bars, which are usually either oval or square with the edges rounded off to prevent damaging or cutting the yarn. When more than one chain is used, as shown, each chain is generally opened out into a sheet, so that the various ends will occupy the same relative positions as in the warper; each chain is passed over a separate bar. After each sheet has passed over its respective bar, they all pass downwards and around the roll b and thence forwards to the loom beam c.

37. Driving.—Power is applied to the front section of the machine by a belt from the shafting of the room, which runs to the tight-and-loose pulleys d, d_1, Fig. 18, being guided by means of a belt fork d_2. On the same shaft with the tight-and-loose pulleys is a three-speed step pulley e, while directly above it is another three-speed step pulley e_1 on a short shaft. On the same shaft with the latter is the first gear f of a train of three gears by which the beam is driven.

The step pulleys give a ready means of changing the speed at which a beam revolves and consequently the speed at which the warp passes through the machine. The slowest speed is obtained by having the belt connecting the step pulleys on the smallest part of the lower step pulley and the largest part of the upper step pulley; the fastest speed is obtained by putting the belt on the largest part of the lower step pulley and on the smallest part of the upper step pulley; while an intermediate speed is obtained by placing the belt

on the middle section of each step pulley. In case the yarn separates easily and is of good quality, the fast speed is used; where a tangled or tender warp is being beamed, the intermediate or slow speed is used.

38. Operation.—The operator stands between the two sections of the machine and operates a reed with one hand and a brush with the other. The reed is of the ordinary type used in a loom and the ends pass through the dents in the same order as leased. If there are 4 ends to a pin, i. e., if the pin lease separates the chain into sections of 4 ends each, then 4 ends will pass through each dent; if there are 6 ends to a pin, then 6 ends will pass through each dent; and so on. The reed is supported by the sheet of ends and is moved slightly to and fro by the hand of the operator so as to open up the sheet effectually without breakage.

After the power is applied and as the yarn begins to be drawn over the frame downwards and horizontally toward the loom beam, the beamer tender constantly passes the brush over the surface of the warp, between the reed and the loom beam; the individual bristles of the brush project between the ends and thus effectually separate them and destroy any entanglement that may have been caused through the dyeing or bleaching or other converting processes.

The overhead system of beaming is used to some extent in the United States and quite commonly in Europe, but only for short-chain warps.

ENTWISTLE TYPE OF BEAMING MACHINE

39. A more common system, especially for long-chain warps, although it can be used equally well for short chains, is the **Entwistle beaming machine** shown in Fig. 19. This beamer consists of two distinct sections—the *head*, or front section, *a* and the *tension*, or rear, section *b*. Between these two sections are a number of minor parts.

40. Passage of Yarn.—A ball or coil of chain is deposited on the floor between the front and rear sections and one end of it passed up over the guide pulley *c*, which

is supported from the ceiling, downwards at an angle to the lower tension drum *d*, then up between two of the guide rolls of the set *e*, around the upper tension drum d_1, down

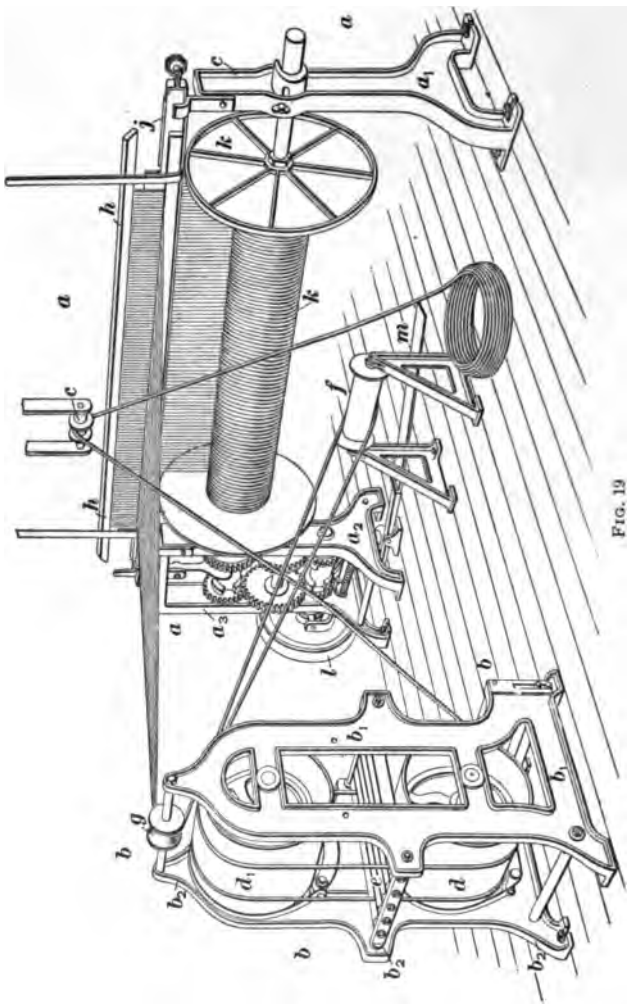


FIG. 19

between two other guide rolls and again around the lower tension drum, then upwards and again around the upper tension drum, from which it passes downwards at an angle

to the return roll f, which is supported by two stands attached to the floor. From the return roll f, the chain passes back to the rear section b, around the return pulley g, and thence forwards to the front section a. On its way to the front section, the chain is opened into a level sheet of ends and passed through the swinging reed h before it reaches the expansion comb j and the beam k.

41. The **tension,** or rear, section b is composed of two upright supports b_1, b_2 that are connected by the necessary rods and braces. The tension drums d, d_1 are supported by these standards and serve to give the chain the necessary tension so that it can be opened properly and wound on the beam with the correct amount of firmness. Between the standards and also between the tension drums is a set of five small guide rolls e, which guide the chain in its passage from the lower tension drum to the upper one, and vice versa. Directly above the center of the upper surface of the top tension drum is a small grooved return, or guide, wheel g from which the yarn passes to the front section.

42. The **head,** or front section, a is composed of three upright supports a_1, a_2, a_3, which are securely fastened to the floor and connected in a proper manner. The uprights a_1, a_2 carry the bearings for the beam on which the yarn is wound and also the expansion comb j, which is of the ordinary construction and spreads out the ends in an even sheet so that they will lie properly on the beam. The beam k is of the ordinary construction, such as is used in the slasher or loom. The reed h is usually suspended from the ceiling by straps, as shown, so that it can be moved back and forth for a short distance. Only one end of yarn passes through each dent of the reed on its passage to the beam. The standards a_2, a_3 support the necessary driving mechanism.

43. **Driving.**—The driving of this machine is accomplished through a friction clutch pulley l so connected to a treadle m that the machine can be stopped instantly, when occasion demands. The friction clutch pulley is connected

to the beam by two trains of clutch gears, so that four different speeds may be obtained.

44. Operation.—After a chain has been placed in position between the front and rear sections and passed through and around the various parts to the beam, the machine is started by the pressure of the foot on the treadle. The operator stands in front of the beam and moves the reed *h* to and fro with his hands in order to effectually separate the threads so that they may pass properly to the beam without breaking or becoming tangled.

45. The floor space occupied by this machine is about 27 feet long by about 8 feet 8 inches wide. The driving pulley is usually about 18 inches in diameter and is driven by means of a $2\frac{1}{2}$- or 3-inch belt at the rate of about 60 revolutions per minute. Measuring clocks are sometimes applied to indicate the length wound on the beam. Beam compressors are also used on certain occasions so that the yarn may be wound more firmly on the beam. This machine can be used for transferring the yarn to loom beams for use in the loom or to section beams for use in the slasher. A beamer of this type will produce about 670 pounds of number 20s yarn in 1 day of 10 hours with an allowance of about $33\frac{1}{3}$ per cent. for stoppages, etc.

46. The beaming process completes the warp ready for the loom on the short-chain system, except for the attaching of the reed and harnesses. On the long-chain system, the warp remains on a section beam after the beaming process and is then dealt with by the method common to the ordinary cotton-warp-preparation processes—several of these section beams are placed in a slasher and there sized and run on tc a loom beam, after which the ends are drawn in through the harnesses and reed, when the warp is ready for the loom. It is this possibility of obtaining a very considerable length of yarn on a section beam that renders the long-chain system more economical, and increases its popularity, especially for colored-goods manufacturing.

QUILLING

CONSTRUCTION OF THE QUILLING MACHINE

47. The last process on the long-chain system for filling yarns is that of **quilling**, in which the yarn forming the chain is wound on filling bobbins, or quills, ready for the

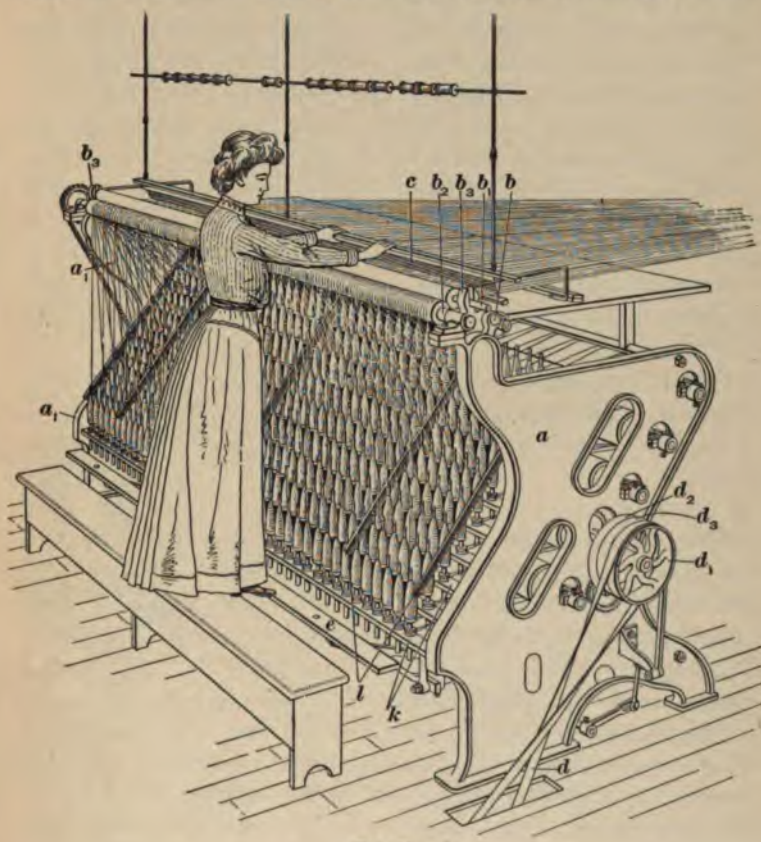


FIG. 20

shuttle. The quilling machine consists of two main sections, the quilling machine proper, shown in Fig. 20, being a substantial framework holding a series of spindle rails, usually

nine in number, arranged in tiers, with 42 spindles in each tier. The other portion of the apparatus is not shown in Fig. 20, but somewhat resembles the rear, or tension, part of the long-chain beaming mechanism shown in Fig. 19, consisting merely of tension rolls by which the yarn is held before passing to the quilling machine proper.

The end standards a, a_1 support three long metal rolls that serve to draw the yarn forwards into the machine. Only two of these rolls are clearly shown, but the extreme end of the third can be seen at b. The rolls b, b_2 are in the same plane and parallel, with only a slight distance between them. They are held securely in bearings at each end, while the roll b_1 rests on top of them, its ends working in vertical slides b_3. The yarn passes through a reed c that is situated directly behind these rolls; then it passes over the roll b, under the roll b_1, and over the other roll b_2. The reed c is suspended so that it can be moved backwards and forwards slightly, in order to properly separate the ends, to prevent breakage, etc.

Power is applied to the machine by means of a belt d, which drives the loose, tight, and slow-motion pulleys d_1, d_2, d_3, respectively, and is shifted by a belt fork actuated by the treadle e.

48. The **spindles**, of which there are 378 in a frame, are shown in Fig. 21, (a) showing a perspective and (b) a section through a spindle and bobbin. The spindle proper extends from f to f_1, the whorl f_2 being rigidly attached to it. Immediately above the whorl is a small pad of woolen felt g, on which rests a cap h, consisting of the lower flange h_1 and the upper flange h_2, in which is inserted a pin h_3, the upper part of the cap being extended to form a sleeve h_4. The **bobbin** j rests on the cap h and is driven either by having a slot cut in its lower portion to fit over the pin h_3 or having a pin j_1 in its base that comes against the pin h_3.

The spindles themselves fit into recesses prepared for them in each of the spindle rails k, Fig. 20, and are driven

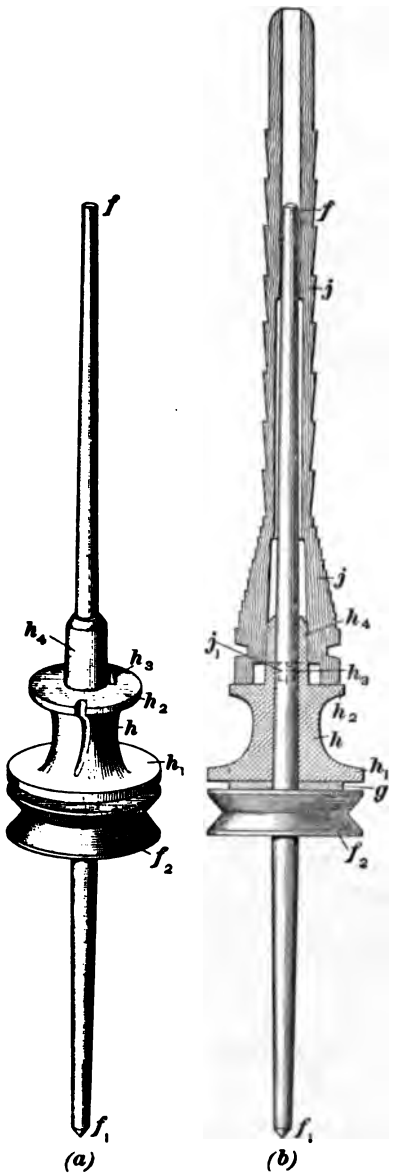


FIG. 21

by spindle bands from a number of cylinders inside the frame that are driven from the main driving shaft. The spindle itself is positively driven, but the bobbin is driven from the cap *h*, Fig. 21, which is supported by the piece of woolen cloth and receives its motion through the friction between it and the upper part of the whorl of the spindle. This friction is sufficient to drive the bobbin at such a speed as to take up all the yarn that is brought forwards from the chain, but in consequence of the drive not being positive, breakage of yarn by excessive tension is prevented.

49. Directly in front of the bobbins are series of guide wires attached to the inclined bars *l*, Fig. 20, which in turn are supported by vertical rods and actuated by **a builder motion** that gives them a vertical reciprocating motion corresponding to the length of traverse required in winding the yarn on the quills. The builder motion used on this machine resembles very closely the filling-wind builder used on

the ring spinning frame. The guide bars *l* are raised a little higher at each traverse, thus building the yarn on the bobbin gradually from the bottom to the top, so that it can be unwound readily from the nose when placed in the shuttle. The builder motion winds slowly in one direction and then returns quickly; thus the return layer of yarn binds firmly to the quill the layer of yarn previously wound and makes a hard bobbin suitable for the weaving process.

The quills commonly used are about 7 inches in length and will contain about 1,900 yards of No. 30s yarn. It will be noticed that the filling does not come in contact with any portion of the machine that tends to burnish it by continual friction.

A quiller of the type described occupies a space of about 4 feet wide by 10 feet 10 inches long without the chain tension head, etc.; with these parts the space required is 10 feet 10 inches by about 30 feet. The main driving shaft of this machine with the belt on the tight pulley should make about 320 revolutions per minute. The driving pulley is usually about 10 inches in diameter and is generally driven by means of a 2-inch belt.

MANAGEMENT

50. Warping and quilling machinery, like all other textile machinery, requires careful attention. In some places high speed and production, as regards quantity, receive the greatest amount of attention, while the quality of the product is ignored. To obtain quality and then quantity should be the aim, and in order to do this to the best advantage, the machinery should be properly cared for. Important points in caring for machinery are oiling, repairing, cleaning, speed, etc. Probably the most important point that is neglected is the proper oiling of the various parts of the machines. All revolving, swinging, and sliding parts should be carefully oiled at stated intervals. The oil should generally be applied in small quantities, as a small quantity of oil in the proper place is far better than a large quantity in the wrong place

and only a part of it in the proper place. The swiftly revolving parts should be oiled twice daily; those parts that move very slowly, once weekly; while those between these extremes should be oiled once daily, every other day, etc.

Repairing is an important point that should always be attended to as thoroughly as possible under the circumstances, no matter what the nature of the breakdown or damage may be. Proper repairing, as well as proper oiling, adds to the quality and quantity of the production.

The cleaning of the machines should be regularly and carefully attended to, especially in regard to removing the lint and oil that collect around or near the parts with which the yarn comes in contact. All other parts should also be kept clean.

The speed of the machine should not be excessive. High speeds can be obtained on almost every machine, but just as soon as the proper working speed is exceeded, the quality of the work will deteriorate.

Piecing-up and doffing should be carefully performed in the manner best suited to the machine under operation. Most tenders have their own ways of performing these operations, yet in the main they are all similar.





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